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THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

SUMMER MEETING.

June 28th-29th, 1934.

THE Summer Meeting of the Institution of Petroleum Technologists was held at the House of the Royal Society of Arts, John Street, Adelphi, on June 28th and 29th, 1934.

The President (Mr. T. Dewhurst), in opening the meeting, said:

The membership of the Institution numbers about 1300, and each and every member receives copies of all issues of the Journal. As the membership covers about 50 countries, it follows that many overseas members are content to keep in touch with the Institution, and with general developments of petroleum technology, solely by means of the Journal. However, we at home have for some time realised that there are insufficient facilities for many overseas members to participate in other activities of the Institution and to meet petroleum technologists from other parts of the world. The Institution holds eight Ordinary General Meetings during the year, from October to May inclusive. The Annual Dinner has always been held during the session, and in recent years in October, at the beginning of each session. The Ordinary Meetings and the Annual Dinner are attended mainly by members who are located in and within easy reach of London and by occasional members from overseas.

We have branches of the Institution in South Wales, Rumania, Trinidad and Persia, and in addition there are many members who are engaged in oilfields and refineries situated in many other parts of the world. Many of these members return to England on home leave periodically, and for climatic reasons, in the period from May to October when the Institution is in recess. I personally know original members who, throughout the whole lifetime of the Institution, have for this reason been unable to attend a single Ordinary General Meeting or Annual Dinner. It is also reasonable to surmise that most of our foreign members who visit our shores, do so during the recess. In view of this position Council decided to hold the Annual Dinner this year on the last Friday in June. The Dinner will be held to-morrow night, and full particulars have been circularised. I am glad to report that many overseas members

have availed themselves of the opportunity thus provided by the Council. It is hoped that the Dinner will be so successful that Council will repeat the experiment, and even that the last Friday in June of each year will become universally known by the members as the fixed date for the Institution's Annual Dinner.

It was also felt that as the Reports on the Progress of Naphthology are published at this time of year, it would be most desirable to hold in connection with the Dinner a meeting at which the Progress Reports could be discussed by members fresh from the oilfields and refineries. It is expected that the Progress Reports will be much improved by the criticism and additional information which can in this way be provided by overseas members. The reports of the Refining and Chemical Section will be discussed at to-morrow morning's session, and the chair will be taken by Dr. F. H. Garner, the Chairman of the Abstracts Sub-Committee, which deals with the preparation of the Progress Reports. In the afternoon the reports of the Field Technology, Geology and General Sections will be discussed and the chair will be taken by Mr. A. Beeby Thompson, who wrote the first of the Progress Reports of these sections.

It was considered that in addition to discussion of the reports on the Progress of Naphthology, advantage should be taken of the occasion to hold special meetings on topical subjects. For example, during the past year the subject of the Format of the Journal has been under consideration, and it was strongly recommended by the Publication Committee, and agreed by Council, that it would be well worth while obtaining the views of members on this subject, and accordingly a meeting has been arranged for this purpose and will be held to-day at 4 p.m. approximately. It is, of course, most fitting that the chair will be taken by Dr. A. E. Dunstan, our Hon. Editor, and that the paper for discussion is by Mr. G. Sell, the Associate Editor.

Another subject of great importance is that of the Measurement of Oil in Bulk, and this will be discussed at a meeting to be held at 2.30 this afternoon with Mr. F. G. Edmed, an Honorary Member of the Institution, in the chair.

In conclusion, I would stress the fact that Council hopes that the attempt to bring together as many overseas members as possible by holding this first Summer Meeting will be attended with such success as to provide encouragement for the holding of an Annual Summer Meeting at this time of year as a normal feature of the activities of the Institution. With this possibility prominently in view, I have much pleasure in declaring this first Summer Meeting open.

Measurement of Oil in Bulk.

Chairman : F. G. EDMED, O.B.E.

The Chairman said that the question before the meeting was one of great importance both to suppliers and to users of oil, and one which had been the subject of considerable discussion by the Standardization Sub-Committee No. 10 of the Institution. Mr. Sanders' paper was a continuation of a previous one* read in 1933 at the World Petroleum Congress.

The following paper was presented :—

On the Advantages Secured by Expressing Quantities of Liquid Petroleum Products in Terms of Volume or Capacity rather than of Weight.

By J. MCCONNELL SANDERS, F.I.C., F.C.S. (Member).†

In presenting his paper Mr. McConnell Sanders stated that the greater part of it was devoted to giving adequate replies to those who had made comments or suggestions relative to the circular letter addressed to them by the Sub-Committee. He did not consider that the ground had been entirely covered, however, and the present meeting provided an opportunity for further ventilation of the subject. Before proceeding to discuss the matter he thought the meeting would be interested in hearing a communication which had recently been received by the Institution from the Admiralty. This communication was as follows :—

"I am commanded by my Lords Commissioners of the Admiralty to refer to your letter of March 20th addressed to the Engineer-in-Chief of the Fleet, concerning a proposal to adopt a volume or capacity basis for the measurement of fuel oil in bulk.

"Consideration has been given to the suggestion, and my Lords would be prepared to accept the change from the present practice of calculating quantities on a tonnage basis, provided that a satisfactory scale of adjustment for temperature is agreed.

"They would propose the Imperial gallon as the Standard unit of volume and 68° F. as the Standard reference temperature."

SUMMARY.

1. Measurement of oil by volume is already in wide use commercially. The practice of expressing quantities of oil in terms of weight is practically confined to those who deal in liquid fuel and those engaged in maritime transport.

* "The Measurement of Oil by Volume." J. McConnell Sanders, *Proc. World Petr. Congr.* 1933, **2**, 866–868.

† Paper prepared on behalf of Sub-Committee No. 10 of the Standardization Committee of the Institution of Petroleum Technologists.

2. Since it is not practicable actually to weigh large quantities of oil, the determination of the volume of a quantity of oil is always necessary in order to obtain, in conjunction with observations of temperature and of density, by hydrometer or otherwise, the weight of the oil.

3. Since the volume of the oil must always be determined whether the quantity is subsequently recorded on a volume or on a weight basis, it is suggested that valuable simplification of procedure would be achieved by using measurement by volume exclusively in commercial transactions and thus eliminating the calculation of weight from measurements of volume, temperature observations and hydrometer readings.

4. It is proposed that agreed tables of coefficients of expansion of petroleum and liquid petroleum products should be made generally available. Such tables are desirable whether oil is measured by volume or by weight.

5. The acceptance in principle of the exclusive use of measurement of oil by volume in commercial transactions does not necessarily involve the general adoption of the same unit of volume and standard reference temperature. It is suggested, however, that the volume of the oil be recorded in all transactions in cubic metres at 20° C., together with, if so desired, the volume in other customary units at specified temperatures.

INTERNATIONAL trade in petroleum and its products is so vast and important that no excuse need be offered for suggesting means whereby commercial trading in the commodity may be simplified and facilitated.

The Sub-Committee appointed by the Standardization Committee of the Institution of Petroleum Technologists to study the matter, discovered at an early stage of their investigations that some remedial measures were necessary and indeed imperative to overcome the widespread conditions of confusion with regard to methods for measuring oil in bulk.

This state of confusion has arisen, in the first place, through the absence of a really international system of weights and measures; and, secondly, through the absence of a uniform method of correlating the diverse systems in current use by various countries which deal in petroleum.

The Sub-Committee has, however, contributed to the latter by the publication of a booklet entitled "Measurement of Oil in Bulk: Part I., Standard Weights and Measures," which contains, among other information, a table of internationally recognised conversion factors.

The introduction of the metric system would undoubtedly have solved many difficulties if it had been adopted universally. That it is not in universal use is proof that custom and national habits of thought are stronger than international agreements, and it is significant that two of the greatest commercial nations, who are the largest dealers in petroleum, although officially accepting the metric system, have failed to put it into practice in their commercial transactions.

It is interesting to note, also, that in the United States, at the time when Col. Drake brought in his pioneer well, petroleum was

at once dealt with as a liquid commodity, and the barrel, already familiar to the early colonists who imported wine and rum from the old country, became not only a convenient receptacle for storage, but also an unlegalised unit of capacity, both of which applications still subsist.

Undoubtedly the manner in which a commodity can be conveniently handled and transported has a great deal of influence upon the unit of commercial measurement. From the barrels carried by barges in Pennsylvania, it was a short step to consider shiploads in terms of such barrels. It is curious, however, that in shipping circles the ton in terms of weight was adopted in preference to the shipping ton of 40 cu. ft., which was already used and recognised for other kinds of cargo.

The wagon-load of oil as used in Rumania was evidently a transport unit, just as was the skin of wine or water used in loading the "ships" of the Sahara. Historically, it is of interest that the oil barrel is of quite ancient origin, although the oil it contained was not petroleum. Still more interesting is the fact that, regarded as measures of capacity, these ancient barrels were far from uniform. The Florence "oil barille" with a capacity of 1946 cu. in. differed from the Leghorn oil barille of 1942 cu. in., which in turn differed from that of Rome, which contained 2240 cu. in.

Both historically and from the standpoint of convenience in handling, transporting and using liquid petroleum products, measures of volume or capacity must appeal to both producers and consumers of the commodity as the essentially practical units to employ, and if we enquire as to the reason for the intrusion of weight units into the picture, we find that the custom is limited to practically two classes of users—namely, those who deal in liquid fuel and those engaged in maritime transport.

In setting forth the advantages of volume measurement as compared with weight determinations, we may confine our arguments chiefly to those considerations which affect the two classes referred to, for in practically no other direction does there appear any reason to anticipate anything but approval, particularly if agreed and accurate tables of coefficients of expansion are made available, a task which is now engaging the attention of the Sub-Committee, with the co-operation of competent authorities.

Users of fuel oil represent a class of the community which for generations has been accustomed to purchase and consume its fuel in a solid form. Fuel represents to them something capable of generating heat units, which, by long standing custom, are more usually referred to on a weight basis.

The age of steam has not yet yielded pride of place to petroleum and "pounds of water evaporated from and at" is still a formula

to conjure with. Undoubtedly it is difficult for the aforetime user of coal, charcoal, wood or coke to think of fuel as physically akin to the liquid which he converts into vapour by its use. With the increasing adoption of the internal-combustion engine, even for large power units, it is inevitable that fuel users will become, if not more petroleum, at least more liquid minded.

In the case of the shipping fraternity, " tonnage " in their every-day vocabulary has a lineage almost as old as the principle of Archimedes, and yet one may pause to enquire why they should be so concerned with the action of gravitation upon the commodities which they convey, seeing that their main object in life is to escape its final consequences.

The Sub-Committee has considered that a very useful purpose would be served if the representatives of fuel users and ship-owners were invited to express their views freely regarding the measurement of oil by volume. For this purpose, a circular letter was addressed to all the principal companies likely to be interested, and a number of interesting replies have been received. Summarising these, it may be mentioned that out of 15 very representative sources, 6 were in favour of the change, 5 were opposed, 3 expressed no decided opinion, and 1 considered it unimportant whether volume or weight were adopted.

It is noteworthy that of the five opponents to volume measurement, four were from fuel users accustomed to the metric system, which we may remark is less subject to confusion and causes of error than the U.S.A. and Imperial systems.

It is considered that subsequent discussion of this paper would be much facilitated if the arguments adduced by the four users mentioned were dealt with in some detail, taking into consideration also remarks made by other users, who, although not opposing, and even welcoming volume measurement, had at the same time contributed useful comments on the case for weight calculations.

The advocates of weight are all fully alive to the fact that actual measurement of the oil must be made in the first instance by volume, and the conversion to weight carried out by calculation, multiplying volume units by density or specific gravity. These advocates were all metric system users, and from their point of view the calculation is a simple one.

They point out that the fuel consumption of a ship has to be expressed in weight units, in order to compare with coal burning ships, and for keeping the engine records.

Apparently, however, these users do not realise that this simple method of calculation may, and probably does, involve an error. The result of multiplying volume by density will give weights of

oil in vacuum, since density is defined as mass per unit volume. The coal-burning ships buy and consume their fuel in terms of weight in air. Consequently the comparison is inconsistent from the start.

There is a further source of error which is not generally realised. Fuel is bought on a specification involving its calorific value.

In the laboratory this calorific value is practically determined by weighing a sample in air against brass, aluminium and platinum weights. It is reported as calories per gramme or B.Th.U. per lb., the weight being uncorrected for air buoyancy.

In the case of coal, this will be bought on a basis of weight in air against cast iron weights, or their equivalent. The difference between the laboratory and commercial weighings as regards the calorific value is, however, insignificant. Taking the density of brass as 8·4 and of cast iron as 7·03, that of coal being taken as 1·5, we find that the apparent weight of a metric ton of coal when weighed with cast iron weights would only differ by about 28 grammes from the result of weighing with brass weights. Since purchases of coal would be made commercially on a weight in air basis, no great error is involved in using the laboratory calorific value as a basis for calculating the commercial quantity of coal needed to furnish a given amount of heat units.

In the case of oil, measured in the metric system, however, the calculation of weight from volume and density measurements results in a weight in vacuum, since densities are expressed in terms of mass per unit volume. Now the amount of oil needed to balance a brass weight in air is greater than that required to balance it in vacuum. Hence, if a sample is weighed in air and its calorific value determined, such calorific value is greater than if it had been weighed in a vacuum.

For example, an oil of density 0·800 g./ml. might be found to have a calorific value of 11,000 calories per gramme, when a 1 gramme sample was weighed in air with brass weights. If it had been weighed in vacuo, the same quantity of oil would have been found to weigh 1·00136 grammes, and the calorific value per gramme would have been 11,000 ÷ 1·00136, or 10,985 calories.

In the accompanying Table No. I. are listed the results of some actual determinations of calorific values ascertained in the usual manner by weighing the samples in air, and from these results are calculated calories per kilo and per litre on both an air and vacuum basis.

It will be noticed that whereas columns C. and D. showing calorific value on a weight basis are different, columns E. and F. showing calories on a volume basis are identical. The table also shows that heating value on a weight basis decreases, while that

on a volume basis increases with increasing density. As regards variation between oils differing somewhat in density, the volume basis is, if anything, more favourable in the heavier grades. For example, oil of density 0·912 has a calorific value of 10,624 calories per kilo, whereas that of density 0·954 has 10,358, a difference of 2·5 per cent. The same oils on a volume basis differ by 1·97 per cent.

TABLE I.

Calorific Values of Petroleum Products.

A. Sp. Gr. 15/4°C.	B. Apparent weight in air Kilos per litre at 15° C.	C. Calories per Kilo in air (observed).	D. Calories per Kilo in vacuo (calculated).	E. Calories per litre in Air.	F. Calories per litre in vacuo.
0·704	0·7029	11,769	11,750	8,272	8,272
0·720	0·7189	11,565	11,547	8,314	8,314
0·723	0·7219	11,510	11,492	8,309	8,309
0·746	0·7449	11,421	11,404	8,507	8,507
0·774	0·7729	11,217	11,201	8,669	8,669
0·796	0·7949	11,168	11,152	8,877	8,877
0·821	0·8199	11,083	11,068	9,087	9,087
0·833	0·8319	11,020	11,005	9,167	9,167
0·847	0·8459	10,892	10,878	9,214	9,214
0·857	0·8559	10,841	10,827	9,279	9,279
0·872	0·8709	10,824	10,816	9,431	9,431
0·912	0·9109	10,624	10,611	9,677	9,677
0·934	0·9329	10,387	10,375	9,690	9,690
0·939	0·9379	10,375	10,363	9,731	9,731
0·950*	0·9489	10,379	10,367	9,849	9,849
0·954*	0·9529	10,358	10,346	9,870	9,870

* These two oils were derived from a different crude.

In the lighter oils the advantage is more with the weight basis, *e.g.*, between oils of 0·704 and 0·796 density, there is a difference of 5·1 per cent. in calories per kilo, and 6·8 per cent. in calories per litre. In any case it would appear that there is no justification for the assumption that the adoption of a volume basis of measurement would involve 10 per cent. differences compared with a weight basis, as mentioned by one advocate of the weight basis. The engineer who has to use fuel oil can be provided with its heating value in calories per litre, or B.Th.U. per gallon, and he can measure the consumption at the burners or the output of heat per unit of volume per hour far more easily and with less chances of error than if he had to convert his measured volumes to purely theoretical weight. Incidentally, it is quite customary to speak of fuel consumption by internal-combustion engines in terms of pints or litres per hour.

Some of those who replied to the circular letter referred to the simple matter of obtaining weight by multiplying volume by specific gravity, but here again the result will be weight in a vacuum, since instruments designed to indicate specific gravity are usually, but

not necessarily, calibrated to show the ratio of the weights of equal volumes of oil and water, both weighings being made in vacuo.

It seems practically certain that many users of fuel oil have for long been accustomed to make their calculations on an erroneous basis, using the calorific value of an apparent weight of oil in air, to estimate their oil requirements, while actually purchasing a weight in vacuum and deceiving themselves with the belief that they were getting an apparent weight in air.

It has been suggested that this error is to the advantage of the seller, but this is obviously not the case. Appendix 1. demonstrates that the quantity of an ordinary fuel oil required by a plant will be over-estimated to an extent of about 0·1 per cent., by assuming that volume multiplied by density gives weight in air.

Another argument put forward in favour of measurement of oil by weight is that volume is affected by change of temperature, whereas weight is invariable. This is perfectly true, and would be a sound argument if actual weight units could be dealt with in practice, but the calculation of weight has in practice to be prefaced by measurement of volume, hence temperature has to be reckoned with in any case.

The effect of temperature is, however, not very formidable. The following table shows it for two different types of oil :—

	Diesel Oil.	*Boiler Fuel.*
Calorific value. B.Th.U. per U.S. gal.	Sp. Gr. 60° F./60° F. 0·855.	Sp. Gr. 60° F./60° F. 0·950.
At 60° F. ..	139,604 ..	149,897
At 100° F. ..	137,309 ..	147,699
At 125° F. ..	135,838 ..	146,278

The difference in calorific value for a temperature change of 65° F. is less than 3 per cent. for either of the oils in question, and this is within the range of the summation of experimental errors. From a practical standpoint, therefore, and over probable temperature ranges, temperature is without significance.

One large consumer of fuel oil suggests that the volume basis, if adopted for selling purposes, would require an adjustment of prices between fuels of different specific gravities, seeing that the user must purchase a greater volume of low specific gravity fuel to obtain the same amount of heat units.

The lighter fuels have greater calorific value per unit of weight and, other things being equal, command a higher price, which would be relatively higher than that of the heavier oils, whatever the unit of measurement.

When comparing two oils of different specific gravities in order to meet a given heat requirement, the order of comparison is not

greatly different, whether weight or volume is used, but the possibility of error is greater with the former.

For example, if a consumer wishes to purchase 100 million calories, he can obtain this from 10,334 cubic metres of oil with a specific gravity 15° C./4° C. of 0·912 or from 10,154 cubic metres of oil having a specific gravity 15° C./4° C. of 0·950.

If he buys by "weight" he is liable to have his requirements met in three different ways :—

	Oil of Sp. Gr. 0·912. Tons.	Oil of Sp. Gr. 0·950. Tons.
1. By Mass (metric system)	9,424	9,645
2. Weight in air	9,411	9,632
3. Apparent weight in air (weighed with cast iron weights)	9,413	9,634

The kind of "weight" he will actually get is variable according to the manner by which the specific gravity is determined. By using a hydrometer he will probably get (1), although if he is comparing his oil with coal he may think he is getting (3). While, as far as its effect upon the ship's draught is concerned, he ought to consider (2) as the correct weight.

As regards the relative cost of the two oils, the volume ratio is 1 : 1·018, while the weight ratio is 1 : 1·023. Hence, it is clear that no adjustment is necessary ; in fact, for all practical purposes, he could obtain his heat requirements by 10 cubic metres or by 9½ tons.

So far the objections we have dealt with are those advanced by metric users, and, as already stated, these are not confronted with the same elements of confusion as the users of the other two systems of measurements. Confusion arises when oil passes from system to system in its commercial travels, and this is where the great advantage of the volume basis becomes evident. Apparently the metric users do not realise this, since their habits of thought as regards weights and measures are based upon a different foundation.

When we consider the diversity in legal or customary definition used in the non-metric systems, such confusion is scarcely surprising. We have the Imperial gallon defined on a weight in air basis, the U.S.A. gallon in units of cubic measure. Weight, as we have already shown, has three different meanings, and hydrometers for obtaining weight from volume may be still more diverse and subject to a multitude of errors, some instrumental, others involving the personal equation, but all of greater ultimate effect on the result than the simple measurement of volume. Storage and ship's tanks may be calibrated in units which have different legal bases, while the oil contained in them may be gauged by

measuring tapes which may not have been calibrated on a uniform system or have any relation to the measurements or temperatures which governed the construction of the tanks.

Theoretically there is no reason why the necessary calculations governing the transit of the oil through the various stages should not be effected with reasonable accuracy and consistence. Experience has shown that, except when the metric system is employed throughout, the contrary is the case, and loading certificates, gauge tickets and other shipping documents record plus or minus quantities amounting to appreciable numbers of tons, which are explained somewhat vaguely as " loss by evaporation " or " through handling."

The main advantage of a volume basis is the elimination of frequent causes of error, often unsuspected by those who most frequently are prone to make them.

It should perhaps be made clear that the agreement to use volume or capacity units refers only to commercial transactions. It does not mean that users of oil are precluded from employing weight or mass if they require to do so.

In fact, one of the companies which expressed agreement to the new basis was careful to explain that their ships' engineers would still continue to calculate the weight of the oil they purchased, since, as they asserted, " this was a simple matter of multiplying volume by specific gravity." We have shown that the matter is not really so simple, but for many technical purposes such a calculation may be sufficiently accurate

The real problem at issue is the adoption of a suitable unit and a common standard temperature. Here we are confronted with the legal aspect of the matter.

In Great Britain both Imperial and metric units of volume are legally available.

Replies to the Sub-Committee's circular letter to consumers show some diversity of opinion on this aspect of the subject. The majority appear to favour the cubic metre with 20° C. as the standard temperature. Two British shipping companies prefer the Imperial gallon, or alternatively the cubic foot, both measured at 20° C., while another British company favours the cubic foot with 94° F. as a temperature reference. Some of the metric users suggest that the time is opportune to adopt the metric system entirely, while one suggests either the cubic metre at 15° C. or the American barrel at 60° F.

It is not absolutely essential that a common volume unit be adopted, so long as the general principle of volume measurement is agreed to, since the customary units are readily convertible by

appropriate factors. Calculations would be much facilitated, however, if a common reference temperature were agreed to, since one set of conversion tables for correcting expansion or contraction through temperature could be universally employed. Hence the solution of the problem would appear to lie in the direction of an international agreement as regards temperature.

It might be internationally agreed to adopt the cubic metre and 20° C. as standard, but at the same time to make it permissible to include tentatively in documents, where required, the corresponding equivalent in the legal or customary units of the particular country employing them. It is suggested that equivalent values, where necessary, should be given in accordance with the following list :—

British Empire : cubic metres at 20° C. and Imperial gallons at 60° F.

United States : cubic metres at 20° C. and barrels of 42 U.S.A. gallons at 60° F.

All metric countries : cubic metres at 20° C.

Thus, cubic metres at 20° C. would always be the basic volume, the other quantity being derived by calculation, the method of doing so correctly being specifically defined.

Appendix 1.

Example.—Estimated heat requirements of plant amounts to 4144×10^8 B.Th.U.

Calorific value of fuel oil :
=18,500 B.Th.U. per lb., weighed in air against brass weights.

$\therefore$ Weight of oil required $= \dfrac{4144 \times 10^8}{18{,}500 \times 2240}$
$= 10{,}000$ long tons.

The conventional method of determining the weight of a volume of oil equivalent to this requirement by multiplying volume by specific gravity would indicate 10,000 tons in vacuum, whereas what is actually required is 10,000 tons in air. The difference for an oil of 0·950 specific gravity, and air of density 0·0012 will be about 11 tons, and the purchaser would thus buy 11 tons more oil than he really needed.

DISCUSSION.

The Chairman remarked that Mr. Sanders had dealt quite clearly with the conditions which, in the opinion of the Committee, would justify the adoption of volume measurement, and with some of the objections which had been raised to the proposal. They had heard that the Admiralty had stated that they would be prepared to make the change, provided that a suitable coefficient

of cubical expansion could be agreed upon. This should not present any insuperable difficulty, but it was probable that several coefficients of cubical expansion would have to be established varying with different types of oil.

The experience of the Admiralty, he continued, was quite at one with that of Mr. Sanders in saying that the errors introduced by the taking of specific gravities reached at times rather amazing proportions. He had often thought that the taking of gravity, quite apart from the inherent errors of the instruments, was a laboratory operation pure and simple and one quite unsuited to the conditions which prevailed on tankers and in other places. The discrepancies between weights loaded at the port of origin and weights noted at discharge, due to taking specific gravities from samples at varying depths, had been known to amount to as much as a hundred tons on cargoes of ten thousand tons, a much greater error than anything to which Mr. Sanders had referred in his paper.

These difficulties were extremely important in a Government Department, where public money had to be accounted for and where a large number of tons short or in excess was equally important. He, as Admiralty Chemist, had therefore been asked whether it would not be possible to eliminate specific gravity determinations on board oilers, and some way of accurately determining the average temperature of oil in a ship's tanks could be found which would enable the volume to be calculated from the gravity supplied and agreed upon at the port of origin. He had therefore started to investigate the question of a suitable method of determining this average temperature.

Continuing, the Chairman suggested that, while the Committee were determining the question of obtaining a suitable coefficient of expansion, they should at the same time seek for a more scientific method of determining the average temperature of the oil in the tanks. Most people, he said, used the method of taking samples from various depths and trying to take the temperatures of those samples after pulling them up through many feet of oil. This was a technique open to considerable error, and he felt that the Sub-Committee should see if they could not agree upon or devise a more scientific and accurate one. As already mentioned, the question had been considered at the request of the Admiralty, and he had come to the conclusion that the only really scientific as well as practical method of determining with any degree of accuracy the average temperature of a tank was to use some type of maximum and minimum thermometer. Several had been tried, and at last his colleague, Mr. Newington, had succeeded, in collaboration with a firm of thermometer makers, Messrs.

Sugdens, in modifying a Sixe's maximum and minimum thermometer in such a way that it had a bulb at the bottom and could be used in a vertical position. Mr. Newington had kindly brought one of these thermometers to the meeting, and any members who desired to inspect it were invited to do so.

It was a fairly robust instrument, and had been so constructed as to be capable of being read quite easily and quickly under conditions obtaining on board ship. It looked somewhat elaborate, but its cost was only about two guineas. It was so constructed that the main alcohol bulb was of large dimensions and was carried to the bottom of the instrument. The indices were quite plainly visible and the scale graduated so as to be read easily and quickly.

A number of experiments had been carried out, determining the maximum and minimum temperature in a tank at 6 to 12 different points from top to bottom and, as a result, it had been found that the average temperature of a tank could be regarded, for all practical purposes, as the mean of the highest and of the lowest temperatures that could be obtained at any point whatsoever in the tank.

To get these two temperatures it was found only necessary to immerse the thermometer

(1) When set to read minimum temperatures, and
(2) To read maximum temperatures at the bottom, middle and top of the tank.

That is to say, the approximate temperature of the tank was determined, and then the index was set, by warming the bulb, several degrees above the lowest temperature anticipated, the thermometer immersed for three minutes at the bottom, raised to the middle, again maintained for three minutes and finally brought to just below the surface for three minutes, after which it was brought out, wiped and read as quickly as possible, avoiding undue exposure to atmospheric conditions. Similarly, for determining the highest temperature in the tank, the index was set well below the highest temperature anticipated by cooling the bulb and again immersed at the three depths for the same time.

The mean of the two temperatures obtained was recorded as the average temperature.

The Chairman, continuing, said that he wished to make it clear that it was not necessary to withdraw and read the thermometer at each depth, the object being only to obtain the lowest and highest temperature in the tank, since the experiments had shown that this method would give a sufficiently accurate figure for the maximum and minimum temperatures likely to be existing at any point in the tank and that the mean of these was sufficiently near to the true average temperature.

The Admiralty had bought six of these thermometers and was trying them at six different ports. It was not yet possible to speak about the results, because the instruments had not been in use long enough. It was, however, felt that with this method more accurate temperature estimations should be obtained than had been obtained by any other known method. One objection to it existed which all members had probably recognised : the measurements took rather a long time. The thermometer in thick oils had a lag of about two minutes which up to the present he had not been able to reduce. It was, therefore, necessary to lay down that the bulb should be retained in each position for three minutes. This meant, therefore, nine minutes for the minimum and nine minutes for the maximum temperatures, a total of at least eighteen minutes in order to take the average temperature of the tank. On the other hand, such a time during the unloading of 10,000 tons of oil was not of very great moment—in fact, it was negligible compared to the time required to supervise the unloading of such a quantity.

The Chairman, in concluding, said that he did not claim that the method, though superior to the present one, was necessarily the best that could be devised, but the question of temperature taking had been somewhat neglected in the past. In some papers read before the World Petroleum Congress the authors had stated that the temperature of the oil should be carefully taken, but had given no indication of how to take it. It would, he thought, be of great value if the Sub-Committee would give some attention to that point. He thought that something on the lines indicated would give more accurate figures than technologists had been in the habit of getting, and, in addition, everybody concerned in the unloading, in the event of dispute, could confirm the temperature much better by such a method than could be done by the ordinary method of bringing up samples.

Mr. E. A. Evans suggested that Mr. McConnell Sanders might help the meeting somewhat if he dealt a little more fully with the differences between the various methods of ascertaining specific gravity, density and such factors.

Mr. McConnell Sanders asked whether, by different methods of taking specific gravity and density, the speaker intended the difference between specific gravity and density and the methods of taking them.

Mr. Evans replied that that was not what he had meant. Mr. Sanders, he said, had referred briefly in his paper to the use of brass and cast iron weights. Presumably one might employ a spring balance or some apparatus of the kind. He would beg for further enlightenment on the various possible systems.

Mr. McConnell Sanders answered that his point was that in the laboratory the practical method of weighing out a sample consisted in weighing it in air. Properly speaking, from a scientific point of view, the weights ought to be corrected for buoyancy of air, but in practical work this was never done. The actual weight of oil that was used for determining the calorific value was the weight in air. When, on the other hand, the weight of a certain bulk quantity of oil was determined by means of a hydrometer, the instrument, being calibrated to indicate the ratio of the weight of a certain volume of oil in vacuo to the weight of an equal volume of water in vacuo, would give the weight of a volume of oil in vacuo. It was therefore incorrect to make a calculation based on the laboratory calorific value and apply it to the commercial weight obtained by hydrometry. This was perhaps not an important matter in the case of coal, because for commercial purposes coal was weighed in air. The only difference was that in the laboratory the sample of coal was weighed with brass or platinum weights, whereas in commerce it was weighed with cast iron weights or something equivalent to them. In the case of oil the difference in density between it and the weights might be great enough to introduce the error. This fact had been pointed out in the paper; although the difference was not very great, it nevertheless constituted one of the errors likely to occur in weight calculations.

Mr. C. Dabell, in dealing with the Admiralty's suggestion that the standard temperature should be 68° F., said that, as in various parts of the world calculations were made to the Centigrade thermometer, the Admiralty's Fahrenheit figure could be accepted, inasmuch that it compared with a round figure of Centigrade. This, he suggested, might prove of considerable assistance to those who dealt with oil abroad.

Mr. A. P. Catherall enumerated certain points in the paper on which he considered that the author might have enlarged. The expression of weights of oil was chiefly, he said, confined to the heavy grades—fuel oil and in certain cases crude oil—and to this side of the Atlantic. The production of the United States was over 60 per cent. of the production of the whole world, and as far as he knew oil was not sold in the United States, except in extremely limited cases, by weight, but almost always by volume. The author had not dealt to any extent with this aspect of the question, and might profitably give the meeting the benefit of his experience of general practice in the United States. He believed that the figure in the United States to which reference was made was 60° F. In fixing a standard figure for reference,

the Institution would find great difficulty in inducing the United States to agree to some figure other than that which they had used since the oil business had started. To lay down a figure of 20° C. when 60 or 70 per cent. of the world's production was measured at 60° F. would be very difficult. It would be very much better to stick to the figure that was already recognised over the greater proportion of the world's production.

The question of coefficients of expansion had been raised, and here again the author of the paper might have enlarged upon the subject. The author had not touched at all upon the excellent tables published by the United States Bureau of Standards, which contained well over one hundred pages of figures dealing with the subject. If those tables were correct—and he had no reason to believe that they were not—there did not seem to be much necessity for dealing with the matter any further.

Mr. E. Lawson Lomax remarked that he did not quite understand the terms "volume" and "capacity." He asked what the capacity of oil was, and whether it was the capacity of containers.

He also referred to the temperatures to which measurements had to be calculated, pointing out that in this country the average temperature of oil in storage only reached 68° F. under very exceptional conditions and on the sunny side of a tank in midsummer. He thought that 60° F. would be a better figure to use over the whole year.

He commented on the question of taking the temperatures in tanks as raised by the Chairman, pointing out that in the case of a 125-ft. tank with nine dip holes, and assuming that it was necessary to keep the thermometer in the oil for three minutes, and heating it for the maximum and cooling it for the minimum temperature or *vice versâ*, the aggregate would he thought be almost a day's work for a man. The method was not practicable from a commercial point of view.

Mr. Lomax said there was a great deal to be said for the measurement of oil by weight. The author of the paper had mentioned that hydrometers were standardized against weight in vacuo. He had been rather disturbed by that statement.

In taking specific gravities by the hydrometer and by the bottle he had found that standard hydrometers checked by the National Physical Laboratory agreed very closely with the bottle specific gravities taken in air and not in vacuo.

On questioning the makers of the hydrometers he was informed that they were standardized as against weight in air. This apparently dealt with the point raised by Mr. McConnell Sanders about liability to divergence in this matter. This was a very strong point in favour of selling by weight.

He had so far spoken about heavy oil or fuel oil, but fuel measurements extended to almost all petroleum products, and Mr. Lomax referred specifically to the case of a road car filled with petrol at about 60° F. which at the end of a long journey might have reached a temperature of 90° F. or 95° F. He said that an increase in temperature of that order meant an increase in volume of about 40 gallons, and he pointed out that if delivered to a garage proprietor who would be charged as receiving the increased volume, when put into underground storage the oil would cool and contract in volume, and the garage owner would then complain about shortage. This was an argument against sale by volume. If the road car were weighed before and after, the purchaser would get a certain weight. The difficulty would be the delivery to the customer from the pump, but as underground tanks were more or less constant in temperature pumps could be calibrated to give practically dead weight. Selling by weight would therefore be a definite advantage. The consumer, the intermediary and the supplier would all receive credit for the definite weight of oil.

Mr. Lomax also cited examples tending to show that in the actual measuring of oil in bulk greater differences could occur than those due to differences in the hydrometer, and since most of the deliveries in this country could be made in quantities for which notation by weight would be suitable, he maintained that weight was the only natural and just method of delivering oil, particularly in the United Kingdom.

Mr. J. Kewley suggested that every member of Committee 10 who had had anything to do with drawing up the paper would agree with what Mr. Lomax had said, that the ideal way of measuring oil from a scientific point of view was by weight. The purchaser of oil was interested in calories ; he was accustomed to have calories expressed in numbers per pound, and if he was given weight he could convert it into calories. He might equally well, however, have calories expressed in relation to units of volume at 60° F. The whole object of bringing up this subject for ventilation was, however, that it was not practicable to measure oil in bulk by weight. It was certainly practicable to measure by weight relatively small quantities of oil in a tankcar quite accurately, but the garages throughout the country were not furnished with weighbridges ; consequently oil was not delivered by weight but by volume, for this obvious reason. The reasons were still more obvious when it came to measuring the cargo of a tank steamer. The steamer could not be weighed, except indirectly from draft measurements before and after loading and discharge, a method so hedged in with difficulties as to be impracticable.

Some speakers were losing sight of the real object of the paper. Granted that weight was the ideal method, it was impossible for large quantities to get weight without getting volume first. The difficulties Mr. Lomax had mentioned applied equally well to measurement by volume, because it was necessary in any case to determine the volume in a tank steamer in order to convert it into weight. The whole point of the argument against measuring by weight was that it superimposed on all the other inaccuracies of measuring by volume that had been described, the extra inaccuracy involved in determining the specific gravity by a hydrometer. The difficulty of determining temperature would always remain, whether measuring by volume or weight. This was the point that had been brought out in the first three paragraphs of the summary and which was being overlooked. Mr. Kewley asked whether there was any fundamental objection to expressing quantities in volume rather than in weight.

Mr. P. C. Pope enquired whether there was any difference in the coefficient of expansion of oils of different specific gravities ; whether this factor would add complication to calculation by weight, or to the calculation of the value of bulk. In other words, he asked, was the coefficient of expansion of gasoline the same as the coefficient of expansion of a heavy fuel oil ?

A Member of the Audience suggested that Mr. Sanders, in mentioning the change which he considered ought to take place, should not forget to take into account the fact that the users of heavy oil fuel, who used the biggest quantity—at any rate on this side of the Atlantic—were shipping companies. Due notice should be taken of the fact that all their calculations were by weight. The calculations in the log books were all expressed in pounds per ton. In taking oil on board ship and calculating the quantity, the questions of unloading some oil and carrying more cargo were all decided by weight. The calculation was made at the place where the weight was taken by an independent party, at any rate in the neighbourhood of the Canal Zone. The independent inspector gave a ruling on what the weight was, and afterwards the figure had to be taken as he had given it, whatever the truth of the weight might be. If the head of the department bought a thousand tons of oil, he had to work out a thousand tons of oil on his log book. Therefore, if there was an error, it was a small and a fair one. The matter had been discussed with his chiefs and they had said that they would be between the devil and the deep sea whether they took it by weight or by volume ; in taking it by weight the measurement was done by an independent person. As shipping firms were the largest customers, their claims should be well looked into before any alteration was thought of.

The Chairman suggested that this reasoning also applied to the Navy, and the speaker agreed that it did.

Captain S. H. Dunlop said that the Navy at present bought and stored the oil in tons, but all the oil fuel tanks in ships were calibrated in gallons, so a certain amount of confusion existed.

Mr. E. A. Evans declared that there seemed to be two separate considerations in deciding whether oil should be sold by volume or by weight. Mr. McConnell Sanders had dealt exclusively with fuel oil, and practically all the discussion had been on fuel oil. There was, however, another side of the industry : the lubricating oil section, where the quantities were obviously much smaller. On this side there was a very definite procedure. Lubricating oil was always sold by weight, and the volume was always estimated on a round figure of a specific gravity of 0·9 : 9 lb. to every gallon of oil. This was accepted ; it was on all invoices and on many of the small packages, and was a recognised custom throughout most lubricating oil organisations, both buying and selling. He fancied, he said, that the lubricating oil section would be rather loath to change, because the practice was so well established. The difficulties could be imagined, because lubricating oil was frequently dealt with hot or comparatively warm. It often left the works at a temperature of 140° F., because at that temperature it was easy to handle. It was perfectly simple to weight the barrels or containers. All the small containers were filled by weight and an allowance was made.

Many arguments had been put forward about the price. It was said that if a lower specific gravity oil could be supplied in the place of a higher, some adjustment of price might be made on one side or the other. In fixing the price, however, all these little adjustments were provided for, so there was really nothing in it (Laughter). The container was never really completely drained, and some sort of heating device would be required to do so. The seller knew perfectly well that he was selling approximately 9 lb. of oil to the gallon.

Captain Dunlop, in amplifying his remarks, said that when the Admiralty bought the oil the contract was made in tons and the oil was paid for in tons and went into the oilers in tons and was stored in tons. It was taken on charge in tons, but all the tanks in the ships were naturally calibrated in gallons, which was the only possible standard of measurement for these tanks. Although the Admiralty had recommended that the Imperial gallon should be adopted as the future all-round standard of measurement, this would lead to a lot of extra figures in the books. In the same way as the shipping companies, the Admiralty would have to convert

from tons into gallons, which meant the addition of two numerals at least to all the figures. The Stores Authorities were, however, prepared to adopt the change, as the Institution had been told officially, in order to put matters on a sound basis.

The Chairman remarked that he had wished to make the point that the change was no worse for the shipping companies than for the Navy, and that the Navy had agreed to go over.

Mr. C. I. Kelly asked whether oil would be sold by volume in view of the possibility that the Institution would decide on the use of volume units for the measurement of oil in bulk, or whether measurement would be by volume and the trade to continue to sell by weight. If the latter became standard practice, the decision to measure by volume would not avoid the difficulties inherent in expressing bulk in tons. For many years past the large companies had used both units as routine practice.

There were many difficulties which would be encountered in laying down the coefficients of expansion of the many varied products on the market to-day. Some oils would be measured by volume at 100° F. in one place and be checked at other localities at say 50° to 70° F. Some would be wholly liquid throughout that temperature range, while others would contain liquid and solid phases at the lower temperatures, due to the formation of waxy bodies on cooling. The coefficients of expansion of the latter would, therefore, not be applicable to the former. Any attempt to collate complete tables would lead to a set of tables more formidable than the Bureau of Standards tables to which reference had been made.

Mr. H. Hyams remarked that to him the question of the purchase and supply of bunker fuels by volume did not appear to introduce any undue difficulty. If the Admiralty or a steamship company purchased a thousand tons of fuel oil, that quantity was checked up and an invoice was rendered for it—once the purchaser agreed the quantity with the seller. If the oil were sold on a volume basis the invoice would be made out, say, for 250,000 Imperial gallons at an agreed temperature, *e.g.*, 20° C. or 60° F. The receiver would take that quantity into his main storage and when a ship was bunkered it would receive a definite quantity of oil in Imperial gallons, once again at 20° C. or 60° F. The manipulation of converting gallons into tons would thus be dispensed with. The weight in tons could not appear in the Admiralty's books or in those of any steamship company without the actual gallonage having first been determined. The change over, particularly from the sale or the purchase point of view, from a tonnage to an Imperial gallonage basis would not, therefore, provide any undue difficulty. There might at first be a little difficulty when changing

the system of recording in log books, until the ship's staff were in a position to calculate gallons recorded from their calibrated tanks to volume at one uniform temperature. That would eventually adjust itself. Nor would the difficulty of recording calorific values in terms of unit volume by any greater, as Mr. Sanders had pointed out, than that of doing so per unit weight.

Another point which had not been stressed in the paper but which one speaker had dwelt upon, was the question of the error introduced by the various bases on which the hydrometer might be calibrated. It had been claimed that the hydrometers mainly in use for measuring bulk oil by weight were calibrated against water in air. Enquiries of the National Physical Laboratory would prove that practically all the instruments which were sent to that centre for checking purposes were calibrated on a vacuo basis. There was not only confusion due to this fact, but it was also invariably and erroneously assumed that gallonage multiplied ten times the specific gravity obtained with a hydrometer—irrespective of its calibration—would give weight in pounds. These advocates of the weight basis were apt, however, to overlook that there were so many bases on which hydrometers were sold for converting Imperial gallons to weight that more confusion existed in that direction than was usually realised. The correct instrument for the purpose in the Imperial system would be one which was calibrated against water in air at 62° F., but hydrometers were sold and used for these calculations which were calibrated against water at 60° F. in air or in vacuo, 4° C. or even 20° C. The difficulty of standardizing on a definite hydrometer which would give definitely and correctly weights in pounds in air—which was wanted in the present case—was probably one of the main reasons that could be advanced against continuing to measure by weight. From the legal point of view, the Board of Trade could not recognise the use of any hydrometer for converting volume to weight. Weighing should be done with a weighing machine, and the hydrometer, whatever basis was used for its calibration, was not recognised. It would be a backward step to endeavour to standardize now a special hydrometer for this purpose. Measurement by volume was the better solution.

Mr. McConnell Sanders, in reply, said that a number of the points which had been raised during the discussion had been dealt with almost automatically, one speaker having given almost exactly the reply to a preceding one which he would have given himself. A speaker had suggested that 68° F. was an inconvenient temperature for this country. This point had been raised by Dr. Anderson the year before at the Congress; he had said that 60° F. was already far removed from what might be called the

ambient temperature in the northern parts of the United States, and that 68° F. would make the matter still worse. Americans would prefer to keep 60° F. There was, admitted Mr. Sanders, a good deal to be said for doing so. This country had, perhaps, a colder average temperature still, and 68° F. was rather a high standard. For that reason he had suggested in his paper that, while the theoretical standard temperature should be 68° F., for present purposes the standard should be 60° F., keeping Imperial gallons at 60° F. and United States barrels of 42 gallons at 60° F.

Apart from this, 15° C. was a temperature commonly in use on the Continent, and was not so far removed from 60° F. that it could not be utilised. The only other way of getting over the difficulty was to standardize measuring tapes at some more convenient temperature. That of 20° C. had, however, been agreed upon internationally, and it was illogical to use any other temperature than that at which tapes for dipping were standardized as the standard temperature of reference.

In the matter of coefficients of expansion, continued Mr. Sanders, one speaker had asked whether one coefficient could be used for all types of oil. The answer was, of course, in the negative. There was, however, a still further and more important point. The tables of the Bureau of Standards, which were so much quoted and used commercially, were out of date. In one sense they were a source of error, because they applied to types of commercial oil which did not represent the average commercial oil on the market at the present day, especially in the lighter grades. The widespread introduction of cracked products into motor spirit, of blends of those cracked products with coal tar products, or even with alcohol, made those tables sufficiently inaccurate to demand a complete revision of the whole subject. It was this complete revision that the Sub-Committee were attempting to undertake. It was a big task and one which would take a considerable amount of time, but, whether volume or weight was the basis, it was necessary. The Sub-Committee might as well, therefore, start on it as a basic task. When accurate coefficients of expansion were obtained, the first step in the measurement of weight was dealt with, because it was necessary to ascertain the correct volume before the weight could be calculated.

The next question was : " Why not leave out the weight, with all its superimposed disadvantages and chances of error, and be content with volume ? " Mr. Lawson Lomax had suggested as an argument for weight the fact that when he took a set of hydrometers, checked by the National Physical Laboratory, to the makers, he found that they were apparently graduated upon

an air basis. Mr. Sanders considered that this was distinctly an argument in favour of volume, since it showed that even amongst the makers of the instruments upon which the weight advocates depended there was considerable confusion. As Mr. Hyams had mentioned, hydrometers sent to the National Physical Laboratory for checking were calibrated on a vacuum basis, and if the makers were under the impression that they were manufacturing them on an air basis there was some confusion somewhere.

One of the main arguments in favour of volume measurement was that it eliminated several such sources of error. One of the speakers had taken his hydrometer to the makers and found out that it was on an air basis when it had been supposed to be on a vacuum basis. That kind of error was continually occurring: when instruments were tested they were found not to be what they appeared to be. Not only the question of temperature, but also the basis of graduation was often a matter of confusion. It was therefore decidedly a step in the right direction to remove the hydrometer from the picture.

Mr. Lomax's question concerning the roadcar had been raised in the United States many years ago and under more provocative conditions. A roadcar which had filled up, perhaps, in northern climates, went right down South until its temperature reached a relatively high degree. Mr. Kewley had sufficiently replied to the question, but Mr. Sanders desired to carry the argument a little further backwards. Before the roadcar had originally been filled the oil had been in a storage tank. It was impossible to weigh that storage tank. Before the storage tank could discharge its load into a roadwagon, it had to be filled from a ship, which could not be weighed on a weighbridge. How, therefore, asked Mr. Sanders, was it possible to balance the two accounts, the amount received from abroad and the amount sold to the public in small quantities by volume? If a weighbridge were to be introduced for checking purposes at an intermediate point, this would simply be another argument for volume, for it would be an attempt to run two separate systems side by side without any proper correlation between them.

The question of temperature was a very important one. The suggestion of using a maximum thermometer had been originally brought up some 12 or 15 years ago by the Mexican Government, who had suggested for it a modification of the clinical thermometer. There was no great argument against it, except from the point of view of its relative response to changes of temperature. It had either to be let down to a definite zone in the tank and pulled so quickly up that it could not alter in the process, or some means had to be devised for arresting the mercury at the given point

that represented only the temperature at that zone of the tank. It was well known to all who were accustomed to handling oil in large quantities that the temperature of a big tank was very difficult to take. One difficulty was in the layering due to the successive quantities of oil which were pumped into the tank from time to time at varying temperatures. The sun would warm one side and a cold wind would chill the other. Short of very extensive dipping in various parts, it was a very difficult matter to get an average temperature. The matter had been studied by the United States Bureau of Standards, and some data had appeared in Wiggin's paper on the evaporation of oil in storage, where this author had described a thieving thermometer which could be sent down and made to take up a small quantity of oil the temperature of which could be assumed to represent the temperature of the zone from which it came.

In reply to Mr. Evans's point concerning the users of lubricating oils, Mr. Sanders said that an established custom was a very difficult thing to overcome, but that if reformers did not overcome established customs they would not progress very far. He did not anticipate any great difficulty in changing a trade custom of that sort. He had been told, and he had it in writing from one of the big distributors of lubricating oils, that the trade did not anticipate any great difficulty in changing this established custom. He took it that his correspondent spoke from authority and that the change would therefore be a fairly easy matter to effect. Obviously, if a large number of containers had to be filled by some kind of automatic machine, it was just as possible to make it work automatically on a volume basis as on a weight basis.

Mr. Kelly had said that the new tables of coefficients of expansion would have to be very voluminous. They would, if they were drawn up with such meticulous accuracy as to cover all possible types and varieties of oil. So far, however, as the Sub-Committee had studied the matter at present, it had been obliged to place a certain limit on the accuracy which was necessary. Its limit had been fixed in the Sub-Committee's contracted ratios as published in its small booklet. Within commercial limits the book of tables need not be a very large one. Some people might prefer to use definite coefficients rather than a set of tables, and this might be the eventual solution of the problem : a set of coefficients for every type of oil, be it lubricating oil, fuel, or motor spirit. It was too early yet to make any prophecy.

The difficulties in sale by volume had been dealt with quite adequately by Mr. Hyams, and he had nothing more to add.

Mr. J. Kewley proposed, and **Mr. E. A. Evans** seconded, the following resolution :—

"That this Meeting is of the opinion that the subject of the standardization of measuring liquid petroleum products in terms of volume or capacity rather than of weight is of such interest and importance that it is worthy of the serious consideration of national standardizing bodies with a view to ultimate international agreement; and that for this reason the Institution of Petroleum Technologists be requested to take steps to have the matter brought to the notice of such bodies for an expression of their opinion."

The resolution was carried unanimously.

Format of the Journal.

Chairman : A. E. Dunstan, D.Sc., F.I.C., F.C.S.

The Chairman said that the referendum, which had been sent to the members of the Institution, had resulted in a vote almost equally divided for and against the suggested change in the size of the Journal. It was therefore felt by the Council that the Summer Meeting presented a good opportunity for further discussing the matter.

The following paper was then presented :—

The Format of the Journal of The Institution of Petroleum Technologists.

By George Sell (Member).
(Associate Editor).

Early in 1933 a proposal was made that the page size of the Journal of the Institution of Petroleum Technologists should be changed from demy octavo ($5\frac{1}{2}$ in. × $8\frac{1}{2}$ in.) to demy quarto ($8\frac{5}{8}$ in. × 11 in.), the typescript to be arranged in two columns. The Council of the Institution considered that the matter was of sufficient importance to refer it to the individual members of the Institution, who were asked to vote for or against the proposal. The advantages and disadvantages of the larger size page were stated as follows :—

"The advantages of the proposal include the following :

"(1) That the number of pages in the annual volume will be approximately half of the present number, and, therefore, when bound the volume will be less dumpy and not so liable to damage when in use.

"(2) That the size would be in line with a number of other scientific societies, such as the Society of Chemical Industry, the Institute of Fuel, the Institute of Marine Engineers, the Institution of Electrical Engineers, etc.

"(3) That illustrations, particularly graphs and curves, could be larger.

"The disadvantages of the proposal include the following :

"(1) That the individual numbers of the Journal, if enlarged, would not be so convenient to carry or read as at present, particularly under field conditions.

"(2) That the Journal, if enlarged, may have to be folded for transmission by post and that the risk of damage would, therefore, be greater."

About 1220 voting papers were sent out, and the total number returned was 179, or 14·6 per cent. This was considered to be a

good return as it was fairly representative of all classes of membership, and particularly as 42 per cent. of the replies were from members resident overseas. The result, however, was inconclusive as 91 of the votes were in favour of the change and 88 against it, and the matter was deferred.

The ballot papers have now been further examined from the points of view of class of membership, place of residence (home or abroad) and occupation. Here again, no conclusion can be reached, as in practically every case opinion was almost equally divided. The one exception was that a slightly larger proportion of overseas members prefer the quarto size.

Although the members were only asked to vote for or against the proposal, several of them made comments. One, in favour of the proposal, expressed the opinion that the change was welcome and long overdue, especially for geological papers. Of the comments put forward against the proposal, four suggested that advantage (l) could also be obtained by binding the annual volume in two parts. One voter pointed out that a change in size would spoil the look of a complete set of the Journal on the library shelves, while another considered the smaller size superior from the points of view of damage in transit, easy reading on draughty verandahs, etc., ease of storage in unbound parts on shelves, and carriage in pocket.

For the purposes of the present discussion, the advantages and disadvantages put forward in the original referendum can be amplified.

The first advantage deals with the bulkiness of a thick volume of small pages as compared with a thinner volume of larger pages. It is quite true that, as has been suggested, this difficulty can be overcome by binding in two volumes, but there are two points in this connection which must not be overlooked. The first is that the cost of binding would be doubled, and the second is that it would be necessary to prepare and print two sets of title pages, indices, etc., the cost of which would be a not inconsiderable item. With the Journal of the Institution there is, however, the advantage that the transactions and the abstracts would allow an easy division into two volumes, although there would a be considerable difference between the thickness of the two volumes.

The advantage that the Journal would be in line with the journals of other societies having similar objects is one of considerable importance. These journals are essential to anyone who wishes to keep abreast of the progress of science and its application to industry, and the advantage of being able to arrange such books on shelves with no waste space, due to varying sizes, will not be denied. In this connection, there has been a definite

tendency during recent years to adopt the quarto page. For example, the Institution of Chemical Engineers and the Institute of Fuel both used the quarto page when they commenced publication in 1923 and in 1927 respectively. Also, the Institute of Marine Engineers changed from octavo to quarto with their Vol. 43 in 1931, and the American Chemical Society did likewise in 1934 with Vol. 56.

The third point in favour of the larger size of page is by far the more important as it refers to the size of illustrations. A perusal of the octavo size journals will show that in many cases the graphs and illustrations are practically useless. Fine points of detail in a line drawing of mechanical apparatus are lost, and small, but perhaps important, changes in the slope of a curve are not apparent. While it may be argued that the cost of blocks would be greater for the larger page, it must not be forgotten that when it becomes essential to include a large drawing in a small-page journal the cost of insetting a folded chart is out of all proportion to the cost of printing on an ordinary page. It should also be pointed out that where a narrow type column is used the smaller illustrations can be fitted into their appropriate position with a smaller percentage of blank area around them.

A further advantage of the larger page is that the typescript can be set in a comparatively narrow column which can be read with greater ease. When the column width exceeds about $3\frac{1}{2}$ in. there is a definite strain on the eyes, caused by the movement in reading along the line and then having to carry the eyes back to the beginning of the next line.

In this connection, experiments* carried out on 400 students of the University of Minnesota in regard to the speed of reading of simultaneous variations of type size and line length showed that 10-point type was the optimum size of type for a line of 19 picas or 80 mm. ($3\frac{1}{8}$ in.). It was also demonstrated that the 80 mm. line, compared with 59, 97, 114, 136, 152, 168 and 186 mm., was the optimum length for 10-point type. Text printed in 8-point type, with a 17-pica line, was read at approximately the same rate as the 10-point, 19 pica.

The disadvantages of the larger page would appear to be small when compared with the many advantages. One might almost express a doubt as to whether the journals of scientific societies are ever read under "field" conditions, except when the reader is comfortably seated in a bungalow.

With regard to the question of transmission by post, the disadvantage of folding can easily be obviated by the use of an

* Tinker and Paterson, *J. Appl. Psychology*, XV, 72–78.

envelope or by rolling in a wrapper with a rip-off strip. In fact the use of an envelope might be considered as an advantage irrespective of the size of the journal, as it would certainly serve to give greater protection than the usual type of wrapper, although it would be more costly.

The stock sizes of printing papers are as follows :—

Name.	Sheet size. In.	Sq. in.	Untrimmed page. Quarto. In.	Octavo. In.
Royal	20 × 25	500	10 × 12½	6¼ × 10
Demy	17½ × 22½	393¾	8¾ × 11¼	5⅝ × 8¾
Crown	15 × 20	300	7½ × 10	5 × 7½

The journals of a number of scientific societies have been examined, and it appears that the quarto page is preferred by chemical publications and the octavo page by engineering and similar journals. Included in the quarto journals are the Bulletin of the American Petroleum Institute, the Institute of Fuel, the Institution of Chemical Engineers, etc.

It is found that, even where the same size sheet is used, there are inconsistencies in such points as the trimmed page size, type area, column width, etc., and these are points which might with advantage be discussed by an appropriate body. There are other matters which also should be generally discussed, such as standard abbreviations, bibliographical references, etc., but these are outside the scope of the present discussion.

When the publication of the Proceedings of the World Petroleum Congress was under discussion, it was unanimously decided that only the quarto page could be used. If these Proceedings had been printed on an octavo page, it would have been necessary to have had four or five volumes.

The essential details of the two page sizes concerned are as follows :—

	Demy quarto	Demy octavo.
Page size, in.	8⅝ × 11	5½ × 8½
Column width, in.	3⅜	4
Type area, in.	7 × 9¼	4 × 6¼
Type area, sq. in...	62 7/16	26
Type area, percentage of page area	65·8	55·6

From the above it will be seen that the quarto page contains 20 per cent. more type area in proportion to the octavo size, and thus 10 quarto pages would be equivalent to 24 octavo pages. This would tend to reduce the cost of producing the Journal and in particular, the cost of binding each issue would be about halved.

It is suggested, therefore, that the most convenient format for the Journal of the Institution of Petroleum Technologists is that which was used for the Proceedings of the World Petroleum

Congress, *i.e.*, Demy Quarto, the type area to be 7 in. by 9¼ in., and the text to be set in two columns, each 3⅜ in. wide, with a rule between the columns.

DISCUSSION.

Prof. J. S. S. Brame objected to the proposed change, principally on the grounds that the individual issues of the Journal would not be so convenient to stack on bookshelves as the present size.

Mr. P. C. Pope (Institute of Fuel) said that the use of the quarto page would result in a saving in the cost of the Journal, and referred to the experience of the Institute of Fuel in the use of the quarto page.

Mr. T. Dewhurst said that he had objections both to the present size and to the larger size proposed, and suggested that consideration should be given to an intermediate size.

Mr. S. J. Astbury referred to the ever-increasing amount of literature dealing with petroleum technology, and was of the opinion that the four-column open page was easier and quicker to read than the present two-column open page.

Dr. F. H. Garner said that he felt that the larger page had definite advantages and suggested that, as the current volume of the Journal was Volume 20, there was a strong argument in favour of a definite decision being made before the commencement of the third decennial period.

Mr. B. J. Ellis suggested that it might be possible to provide a suitable form of binding cover in which the individual numbers of the Journal could be stored without the necessity of a permanent binding.

Mr. G. Sell, in reply, said that the question of storage of individual parts of various journals had been satisfactorily solved in the Institution's Library by the use of storage boxes.

On the question of considering a further alternative size, he did not consider this in any way desirable, as he felt very strongly that all scientific and technical publications should be of one size.

In conclusion, he suggested that a small sub-committee be appointed to consider the various details involved.

The Chairman suggested that the meeting should generally approve the proposal of a larger page and also the suggestion that the matter be considered in detail by a sub-committee.

This was agreed without dissent.

REPORTS ON THE PROGRESS OF NAPHTHOLOGY.

Refining and Chemical and General Sections.

Chairman : F. H. GARNER, Ph.D., M.Sc., F.I.C.

The Chairman said that the first Annual Report on the Progress of Naphthology was issued by the Institution of Petroleum Technologists in 1924, and, in accordance with the suggestion made by the President, it was decided that a day should be devoted to discussion of the Reports at the first Summer Meeting of the Institution.

The Committee responsible for the Annual Reports on Naphthology was a Sub-Committee of the Publications Committee, whose primary work was the abstracts appearing in each Journal. A brief account, therefore, of the work of the Abstract Sub-Committee might be of interest, since the two projects, abstracts and Annual Reports, were necessarily closely connected.

The abstracts were prepared by six groups, composed of representatives of the Petroleum Departments of the Imperial College of Science and of Birmingham University and of four of the larger oil companies in this country. The scheme of abstracts had been so arranged that subjects were referred to abstractors who had specialised in the particular branch under consideration. At the present time there were about thirty-three abstractors, and their names were published annually in the JOURNAL for December.

Actually over a hundred journals were abstracted regularly, and the journals taken by the Institution and available in the Library were supplemented to a large extent by others taken by the various groups mentioned, but made available for abstracting purposes. With regard to the completeness of the abstracts, he thought that those spoke for themselves, and a further important point was that a very short time elapsed between the time of original publication and the date on which the abstracts appeared.

In order to maintain uniformity of style and the same form of abbreviation for journals, a list of instructions was issued to abstractors, and one important point was that abstracts should be as short as was consistent with a clear and accurate statement of the author's views and results, and that the chief function of an abstract was to be informative, so that it should recount the achievements of the work and not merely its scope.

The Institution was greatly indebted to a number of representatives of the various groups who met once a month and carefully considered all abstracts submitted.

The general arrangement of the abstracts had been carefully reconsidered from time to time and slight modifications had been

introduced. Much thought had been given to the most suitable order in which to present the abstracts, and the system now adopted was that given in the United States Bureau of Mines Publication Bulletin 290, which covered the whole range of petroleum technology. It was considered that that system was very much more suitable for the purpose in question than the Dewey system, in which petroleum was only a small section. Thus it would be noticed that first of all came Class 100, which was Geographical Occurrence, then Class 200, Geology and Origin, Class 300, Development and Production, Class 400, Transportation, Storage and Distribution, Class 500, Properties and Their Determination, Class 600, Refining and Refineries, and Class 700, Utilisation.

In addition to journals, brief abstracts were given of the more important patent literature coming under the various headings.

In the last three years particular attention had been devoted to making the abstracts even more complete on the field production and engineering side, since so large a number of the members overseas were interested in that particular aspect of petroleum technology.

The remarks he had made represented an outline of the present system underlying the abstracts as published in the JOURNAL at the present time, but special credit should be given to Mr. W. H. Thomas, who was responsible for the whole of the abstracts appearing in the JOURNAL until 1930.

As he had mentioned, the Abstract Sub-Committee was also responsible for the Reports on Naphthology, which had gradually been developed into their present form. A different scheme of classification had been adopted in the Annual Reports from that in the abstracts, and these were grouped under the following named headings :—

(1) The Field Technology Section, which included drilling, progress in scientific development, control and production from oilfield reservoirs, production technique, transport and storage, and regional reports from a number of countries. (2) The Geological Section, which included this year geology of oilfields, geology of petroleum and geophysics. (3) Reports on Refining and Properties of the Various Products, which included reports on cracking, distillation, chemical and physical refining, and articles dealing with the various products: natural gas and natural gasoline, crude oil, motor spirit, kerosine, lubricating oil, gas and fuel oils, and asphalts. In the case of the fuels, motor spirits and Diesel oil, for the last few years the sections had been divided into two parts, the first being more particularly concerned with the chemical and physical characteristics of those products and the second being a section on the purely engineering aspect. Then there

was a Report on Special Products, such as carbon black, synthetic chemicals produced from petroleum, insecticides, and a number of similar products. The next two reports were on the Analysis and Testing of Petroleum Products and on the Chemistry of Petroleum, and there were also two reports dealing with Motor Benzole and Low Temperature Carbonisation. (4) A Review of Petroleum Literature and a Record of Statistics, giving the production of crude petroleum and other products in comparison with earlier years.

The scheme he had mentioned was not always followed in its entirety, as, for example, it might be considered that sufficient progress or new developments in certain subjects had not taken place during the year under review for a report to be made, and that applied in the present year to distillation, which was fully covered in the two reports for 1932 and 1933. Also, from time to time, special articles on subjects in addition to those mentioned were included, if it was considered that new developments had occurred which would be of special interest to the members.

In the present year a new departure had been made in the publication of a valuable review of petroleum literature by Miss W. S. E. Clarke, which gave a complete summary of the more important books on petroleum products which had appeared during the year, many of which had been reviewed in the JOURNAL, and also an account of new journals, dealing with the particular branch of science in which petroleum technologists were interested, of which the first numbers had appeared during 1933.

The division of subjects into the groups he had named was felt to be advantageous, since it enabled those members interested in one particular aspect of the subject to obtain a review of the progress made in one article, rather than having to read through a number of the Annual Reports.

In reports of the character in question, written by a number of different authors, it was naturally not possible to produce a standardized article, and, even if such were possible, it would certainly not be desirable. A large amount of latitude was left to the individual authors with regard to the material and manner in which they should present the reports, but account was always taken of reviews appearing in previous years, so that, if any outstanding developments had taken place in one year, a relatively large amount of space could be given to that particular aspect, and other matters which had been fully dealt with in previous years were given less attention.

One of the most serious difficulties was that of preventing overlapping in the various articles as much as possible, and it was felt that a measure of success had been attained in that

particular direction. Thus, while the same JOURNAL reference might be made in two or more articles, it would usually be found that the particular aspect from which the reference was being reviewed was entirely different.

In both the Abstracts and the Reports on Naphthology, special reference must be made to the work of Mr. G. Sell, who was so largely concerned with their production and the various improvements introduced from time to time.

The purpose of the meeting that morning was to hold a discussion on the Reports on Naphthology dealing with the refining side. Discussion was invited on two aspects of the Reports, namely: general comments on Annual Reports as regards the form and scope of the matter presented; and, secondly, discussion of particular subjects included in the Reports.

With regard to the papers which were to be considered, it was quite impossible to call on the various authors in every case to present a summary of the Reports, but it had been felt advisable to have a few brief reports of one or two sections, and those would indicate subjects to which discussion might usefully be devoted. Two questions which appeared to him of outstanding importance at the present time were the refining of lubricating oils by means of the various solvent processes and the question of the quality requirements of Diesel fuel.

As one of the main objects of the Annual Meeting being held in the summer was to afford an opportunity for overseas members who might be in this country at the time to take part, discussion from such members of the Institution would be particularly welcomed.

The following papers* were presented for discussion :—

"The Cracking Art in 1933," by G. EGLOFF and Miss B. L. LEVINSON.

"Chemical and Physical Refining," by C. G. VERVER and R. N. J. SAAL.

"Natural Gas and Natural Gasoline," by Miss T. HOFFMANN.

"Crude Oil," by W. H. THOMAS.

"Motor Spirits and Light Distillates," by E. B. EVANS.

"Gasoline Engines and Knock Testing," by C. H. BARTON.

"Kerosine and White Spirit," by J. S. JACKSON.

"Lubricants and Lubrication," by A. R. BOWEN.

"Gas Oil, Diesel Oil and Fuel Oil," by C. G. VERVER.

* See pp. 343–523, 636–662.

"Oil Engine Developments and the Testing of Diesel Fuels," by R. STANSFIELD.

"Asphalts and Road Materials," by J. GREUTERT and R. J. FORBES.

"Special Products," by S. F. BIRCH.

"Analysis and Testing," by C. CHILVERS.

"Chemistry of Petroleum," by G. R. NIXON.

"Motor Benzole," by W. H. HOFFERT.

"Low Temperature Carbonisation," by F. S. SINNATT.

"Petroleum Literature," by Miss W. S. E. CLARKE.

"Statistics," by G. SELL.

DISCUSSION.

Mr. C. H. Barton, dealing with the subject of Gasoline Engines and Knock Testing, said that the subject of knock testing of motor spirits continued to receive a great deal of attention, and the C.F.R. Committee in America had arranged to carry out a series of tests with production engines on the road during July. The procedure for those tests was on the same general lines as that of the first series of road tests carried out by the C.F.R. Committee in August, 1932. At the forthcoming tests the I.P.T. Knock Testing Committee would be represented by two members, namely, Messrs R. Stansfield and C. H. Sprake.

On the question of the testing of gasolines for detonation on the road, there was some difference of opinion as to whether the "knock extinction" or "maximum knock" method was the most satisfactory, that is, most nearly represented the observations of the average car driver. In the knock extinction method the engine was accelerated or decelerated until knocking ceased or began, and the speed at which detonation stopped or began was recorded. In the maximum knock method, gasolines were graded according to the intensity of the detonation which they produced, and no account was taken of the engine speed at which the observations were made. The latter method, which was developed by the C.F.R. Committee, was probably the most suitable for those engines which were provided with both centrifugal and vacuum ignition control.

An interesting point about knock testing on the road was the difference found in the results on the same fuels in the various engines. These discrepancies had not been correlated with engine design, but they were probably due to local differences in cylinder temperatures between the engines.

In view of the great amount of attention given to the question of detonation in motor cars, it was worth pointing out that, owing to the relatively small proportion of the maximum power output required from the class of engine in question, for the greater part of its working life, detonation was probably of no greater technical importance than were normal gear noises. Except in rare cases, the intensity and duration of knocking, even on a poor fuel, was quite insufficient to produce mechanical damage.

A good deal remained to be done by engine designers in reducing the knocking tendencies of their engines. To illustrate the effect of design on the fuel requirements of an engine, he would like to refer to the case of two British production engines of similar capacity and both of high power output, that is, of high mean effective pressure. The compression ratio of the engines was about 6·5 to 1, and in one case a fuel of over 80 octane number, determined by the C.F.R. method, was required to eliminate detonation, while the other engine operated with almost undetectable detonation on a fuel of about 65 octane number.

So long as the conditions under which detonation occurred were those of low engine speed and low piston temperatures—and the second factor was largely affected by the first one—then it seemed that little mechanical destruction was brought about by detonation. For example, no single-cylinder knock-testing engine, such as the C.F.R. or any of the other engines used, had, as far as he was aware, ever shown any ill effects from detonation, although most of the running of the engine took place under conditions of continuous and severe detonation. In the C.F.R. engine, for example, the standard running speed was 900 r.p.m., and there was no doubt that the piston was relatively cool, although the cylinder jacket was maintained at 100° C.

On the other hand, in the case of a small air-cooled, single-cylinder engine which was not a standard detonation tester, running at 3000 r.p.m. with a mean effective pressure of 100 lb. per square inch, continuous slight to moderate detonation had been found to produce perceptible burning of the top band of the piston within an hour or two. The conditions in the latter engine apparently approached those which held in air-cooled aircraft engines, in which burning of the piston was a frequent result of detonation. For that reason, the subject of knock rating on aviation fuels was, in his opinion, of far greater importance than that of motor gasolines.

A considerable amount of work had been done on the knock testing of aviation fuels, but it seemed that a great deal more investigational work was required before satisfactory methods could be put forward for determining in a small testing engine

the relative performance of fuels in full-sized aircraft engines which were working under really severe conditions.

Mr. J. S. Jackson, dealing with the subject of Kerosine and White Spirit, said that kerosine had not attracted a great deal of attention, but, nevertheless, more work than usual had been done during the past twelve months. Some of this work had, however, been rather misdirected. Endeavours were still being made to refine kerosine by methods directed principally towards the removal of aromatic bodies, whereas efforts in the direction of improving the methods of burning kerosine would have been much more productive.

Mention had been made of the hydrogenation of kerosine, but it was felt that the application of this process to kerosine was rather a waste of effort. The kerosine that was used as a basic material for hydrogenation could probably have been satisfactorily refined by ordinary methods and rendered suitable for many purposes.

Discoloration problems, are, however, of distinct importance, as the petroleum industry must take particular notice of the colour of kerosine.

Interesting papers had been published by Mr. McHatton and Mr. Hillman, and the "Hillman Test" (the lead peroxide test) had proved extremely useful in foretelling the colour stability of kerosines. The test was a simple one and had been applied successfully in refineries for the control of the refining process. Mr. McHatton's paper indicated that discoloration was due largely to the presence of phenolic bodies and nitrogen compounds. The Hillman test, supported by the silico-tungstic acid test, which indicates the presence of nitrogen compounds, will give a reliable indication of the length of time that the kerosine would remain colour-stable.

The Standardization Committee had evolved a modified smoke point apparatus. A good deal of publicity had been given to it, because it was felt that it was a very convenient, practical and useful test, by which, in the course of a few moments, the burning properties of a kerosine could be determined.

A lamp was shown to direct attention to a further modification of the method of operating the candle. The original method had been found mechanically unsound and rather fragile. In the suggested arrangement the sheath in which the candle is fixed is threaded. The sheath is then raised or lowered by means of a threaded ring fixed to the body of the lamp. The provision of a solid and heavier base is also recommended. As a development of the burning test it had been suggested that the amount of

char formed on the wick during the burning test should be determined, It was felt that this char figure gave a valuable and comprehensive measure of all the undesirable features of the kerosine.

Miss W. S. E. Clarke said she had been asked to give a short *résumé* of the contributions to the Naphthology Reports coming under the title of "Petroleum Literature." It was the first report of its kind, so naturally it was rather difficult to know how to set about the preparation of it. Its purpose was to give a representative review of the literature published in 1933, while endeavouring not to omit any particular branch of the various sections of petroleum technology.

With regard to the scope of the paper, it had been found quite impossible to mention all the publications for 1933 in the text, but those of lesser importance than those mentioned individually in the report were quoted in the bibliography appended. The bibliography might seem long, and in parts irrelevant, but it actually consisted of books, pamphlets and journals which from her experience had been required for reference.

She had relied on the reviewers' opinions of the books, although she had seen quite a number of the books herself. The review of a book was more complete and critical than an abstract of a book, since an abstractor's opinions were from a different viewpoint.

As for the paper itself, it covered the various branches of the petroleum industry and was sub-divided under a number of convenient headings.

The publications dealt with comprised English and foreign books as well as pamphlets, and a separate section was devoted to new journals. Wherever possible the publishers and prices of the publications were given in the bibliography at the end of the report.

Summing up the literature, there seemed to be a paucity of published work on the geology and production of petroleum, which might be due to political reasons, but, on the other hand, the refining, chemical and engineering sections were comparatively well covered.

The Proceedings of the World Petroleum Conference would remain as works of reference.

There was one suggestion she would like to make. One of the functions of the abstracts of articles appearing in the JOURNAL was to provide a convenient means for the chemist, the geologist or the engineer to select for careful reading accounts of recent thought or work which bore on his particular subject. She would suggest, therefore, that, in order to make that function of the JOURNAL more complete, reviews of books should be

included with the abstracts, and also additions to the Library under the appropriate headings; for example, the review of a book on petroleum geology would appear at the head of the section of abstracts dealing with geology. That would bring together all the literature, books, pamphlets and abstracts of articles from current journals.

In conclusion, in view of the fact that the report with which she had dealt was the first of its kind, constructive suggestions would be very welcome, in order to make the next report on the subject more complete.

Dr. A. R. Bowen dealt with the subject of Lubricants and Lubrication. He said the subject of the solvent refining of lubricating oils was of outstanding interest. The theory of this process had been investigated some years ago and several laboratory-scale experiments had indicated the practical significance. It could be really looked upon from two different angles: the organic chemical side and the physical chemical or the chemical engineering side. Both presented a wealth of subjects for future research.

With regard to the chemical side, the action of solvents on petroleum fractions was well known. Petroleum fractions were particularly amenable to solvent extraction owing to the great differences in the types of hydrocarbons they contained. The Edeleanu process was an early application, being developed for refining kerosine. That process had been applied to light lubricants, but for heavy lubricants the selectivity of the solvent used was perhaps not quite that required. Accordingly, mixtures such as benzole and liquid sulphur dioxide had been tried and they had been found to give better results. Another solvent which showed possibilities was aniline, and in that connection he would mention the work of Mr. Carpenter, of the Burmah Oil Company. The aniline point method in the analysis of a spirit involved the same principles.

On the research side, the value of solvents to split a petroleum fraction, such as a lubricating oil, into two distinct series of hydrocarbons had been brought out by a number of investigators. He would mention Maybery's work on lubricants, where he washed his lubricating oil fractions with alcohol and ether mixtures and got two very different types of oils which he called the D. and H. series and also the work of Mr. H. M. Smith, of the U.S. Bureau of Mines. Mr. Maybery found that the extract had a steeper temperature viscosity curve and was not so stable chemically as the raffinate. Then he would mention the work of Wilson and Allibone, who found that Burmah oil fractions on treatment with sulphur dioxide and sulphur dioxide-acetone

mixtures gave extracts and raffinates of extraordinarily different properties. It was quite amazing to take a spindle oil fraction of sp. gr. about 0·87 and wash out from it an oil of sp. gr. just over 1. That was the sort of extract that could be obtained with such solvents as those he had mentioned.

In the United States a determined effort had been made recently to find the most suitable solvent for the type of refining treatment in question, which avoided the usual refinery loss and simply divided the oil into fractions. In that connection, the work of Ferris, of the Atlantic Refining Company, should be mentioned. That investigator, with his co-workers, tried the action of some 110 different organic liquids, including nitriles, ketones, aldehydes and hydrocarbons, in order to find the most selective solvent for the work. Nitrobenzene was finally chosen.

Another solvent was phenol. The Burmah Oil Company held a patent on that, and the Imperial Oil Company, through the work of Dr. Stratford, had also patents mentioning that substance. Phenol seemed quite a useful solvent.

This indicated some of the work using one solvent. Then work had been done utilising two solvents. The most notable process in that connection was the process of Max Miller, namely, the Duo-Sol process, in which he treated his lubricating oil fractions with cresols and liquid propane. The cresols had the advantage of washing out the less desirable constituents and the propane was a better solvent for the paraffinic-type constituents. The introduction of the liquid propane had several other features. It had the tendency to precipitate asphalt and also, on evaporation, the chilling effect could be used in dewaxing.

That covered briefly the organic chemical side of the problem. The other side was the physical chemical side, which is associated with the chemical engineering development. The mixing of two liquids, one containing a mutually soluble substance, was governed by the distribution law. The simplest case would be a single contact, and such contact between the two liquids could be made by agitation or, better still, by treatment in an orifice column. Single contact could not wash out more than the distribution law allowed, and this fact leads to consideration of a multi-stage contact. Here there would be a number of different stages, up to, say, n stages. Several problems now arise: how much solvent to use, in what proportions to use the solvent in the different stages, and so on. The next step would be to make such a refining scheme more continuous, and that led to the counter-current method of washing the lubricating oil with the solvent. The simplest type of plant for counter-current treatment would be the

batch counter-current type, and more efficient, perhaps, would be the continuous counter-current type using a packed tower.

At the University of Birmingham, research on the physical chemical and chemical engineering side had been carried out recently, and certain mathematical equations had been evolved to cover the washing effect on a lubricating oil fraction. It had been possible to take some simple cases and check up the actual physical constants and the results from the mathematical equation. At the University they had been indebted to Dr. Ferris for some figures obtained by the washing of a lubricating oil fraction with nitrobenzene. Dr. Ferris and his co-workers had amassed a great deal of information, and the workers at the University of Birmingham had been able to plot Dr. Ferris's figures on the physical properties of the extract and raffinate with their mathematical results. The curves coincided quite satisfactorily.

The packed tower type of plant involved many problems. The intimate contact of the solvent and the lubricating oil fraction was not an easy matter. The tower might be packed with rings or baffle plates and problems arose out of the possible channelling of the two liquids and the tower not functioning in the ideal manner required by the theory. The whole subject abounded with possibilities for future research, both on the organic chemical and perhaps still more on the chemical engineering side.

Mr. E. A. Evans said he was particularly interested in Dr. Bowen's report, which he had presented very lucidly. A man who was called upon to write an Annual Report was faced with an enormous amount of literature, some of which was excellent, some of which was probable and a lot less probable. The writer of the report had to decide whether he should confine his attention entirely to those points which were obviously right or whether he might put himself in a jeopardous position by referring to those things which were definitely less probable.

He would like to take Dr. Bowen's report in order to illustrate what he meant, and he thought Dr. Bowen might agree that those points could be left out of the report.

For example, Dr. Bowen had referred to a statement that Paraflow had no effect on aircraft oils. Paraflow had its definite uses, and surely it was wrong to say that all aircraft oils were unaffected by Paraflow.

Dr. Bowen had referred to upper cylinder lubrication. There was a terrific war going on at the present moment about cylinder wear, and it must be obvious, he thought, to most of the members that there was at least some association between upper cylinder lubrication and cylinder wear.

With reference to specifications, Dr. Bowen said that a certain Mr. Nutt was disposed to discard oil specifications entirely and to rely exclusively on engine tests. If that became a recognised procedure it would be rather an expensive matter, he thought, for the petroleum industry. If everyone had to buy turbines, aero engines, etc., and wait for the engine tests to be carried out, they would not get very far. They had to rely on experience. It might be rather hazardous, but there was a certain amount of fairly shrewd guessing going on. He did not think anybody could definitely dispense with specifications, and he thought it was extremely dangerous to say that one must rely on engine tests entirely.

With regard to wire drawing, in a modest kind of way he had had a certain amount of experience of the subject, and he certainly would feel very apprehensive or timid in suggesting any ammonium soap for that particular purpose.

Extreme pressure lubricants had been referred to. It must be recognised that the details of the manufacture of extreme pressure lubricants at the present time was essentially a fairly closely-guarded secret. It was known that certain products were sulphurised, and there were various ways of making them, but he did not know of anybody who was making them in the same way as that described in the general literature. In this country there were, he thought he might say, only two extreme pressure lubricants. He himself was responsible for one of them, but he did not use, as was suggested in the report, a saponifiable oil of mineral origin—in fact, he did not know what that was!

There was one statement made in the paper with regard to extreme pressure lubricants, namely, that it was necessary to heat a lead soap with the oil to 400° F. to obtain the maximum efficiency. He could assure the members that a much lower temperature was sufficient to get most lead soaps into a mineral oil.

Captain King's paper had been the subject of a great deal of discussion, and he thought that many people had misunderstood exactly what Captain King had in mind. Captain King did not suggest that by blowing an oil or oxidising it one produced polar bodies. Captain King's one point was oxidation activity pure and simple, that was, there was a sort of activity going on on the surface of the metal between the oxygen and the oil.

The points he had mentioned were really the points in the report with which he did not agree, and he hoped they would serve to illustrate what he meant by the less probable points in the report. He was sure that anyone who wrote any of the reports had done an exceedingly hard year's work and deserved every appreciation.

The Chairman said Mr. Evans had certainly raised a very important point with regard to the scope of the reports. It should be understood that the reports were intended to be a summary of the literature. The authors naturally could not accept responsibility for opinions expressed by other people. Obviously, the most important point was that the reports should be as complete as possible.

Dr. Bowen said that Mr. Evans had raised a point in the question of Paraflow. In the report last year reference had been made to the original publication of the discoverers of that substance, Messrs. Davies and Blackwood, and he himself went into the subject very carefully. The two investigators whose work Mr. Evans had mentioned, namely, Professor Suida and Herr Pöll, had investigated the action of Paraflow on heavier types of lubricating oils.

With regard to the question of upper cylinder lubrication, that, of course, was a controversial matter, and he had merely recorded the opinions of a man who had done a great deal of work on this subject.

With regard to the point that a specification of an aero-engine oil may not always be sufficient for its evaluation, that was a statement of an engineer of high standing.

With regard to the question about wire drawing lubricants, that again was a subject on which there was very scanty published matter. Therefore he thought that what little had been published should receive passing mention, and the same really applied to extreme pressure lubricants. Petroleum technologists were all very interested in these new lubricants and, although they realised that the subject was one of some secrecy, the few papers that had appeared had been treated at some length, because he thought much of the ground would be covered again by scientific investigators.

Dr. H. G. Shatwell asked if Dr. Bowen could tell him which of the three cresols was used in the solvent extraction of lubricating oils. He asked that question because there were very considerable differences in the physical and chemical properties of the three cresols. For instance, in the production of synthetic resins one of the cresols, the meta, was the most valuable, whereas the ortho was the least valuable for that purpose. It had therefore occurred to him that probably there was some difference in the solvent properties of the cresols.

Dr. Bowen said that for the Duo-Sol process, Mr. Max Miller had mentioned a special blend of coal-tar acids rather than a pure chemical substance to be used with liquid propane.

Mr. C. Chilvers said the value of the reports was chiefly as an indication of sources of information which might have been overlooked during general reading. To serve that purpose, the reports must cover not only the more important papers published in the more widely-read journals, but also information obtained from more obscure sources. If that was done, an investigator, provided he could rely upon the comprehensive character of the reports, could obtain a complete picture of the scope of the work that had been done in any particular phase of the industry during the year or during the period under review, and he thought the value of such reports was obvious to anyone who had much literature-searching to do.

A further point was that it was very difficult to say just how much of the published literature could really be included under the heading "progress." It would possibly be more satisfactory if the title of these reports could be altered to "Review of Naphthology."

With regard to analysis and testing, there was, of course, a very wide scope for the analytical chemist in the petroleum industry, but the importance of interpretation of results could not be over-emphasised. There were, in fact, too many methods published which could never be of much more than academic interest. There was a definite tendency, however, to attempt to correlate specific tests on a product with its behaviour in practice. For example, the distillation test for gasolines had been related to starting characteristics, vapour-locking tendency and dilution of the lubricating oil. In the case of oxidation of lubricating oil, however, the test which was supposed to indicate the carbon formation tendency in the engine, he thought a great deal more work was required before any definite correlation could be claimed. There was an increasing tendency to apply mechanical tests to lubricating oils as a measure of oiliness, but in that case he doubted if any two of the machines described would give comparable results.

In testing bituminous materials also, attempts were being made to devise methods to enable some information to be obtained on the behaviour of the material when applied to the road, and that perhaps applied particularly to emulsions. There had been a number of breakdown tests published during the year, but it was doubtful whether any one of them really took into consideration all the various factors which were involved in the drying out of an emulsion upon the road.

He thought the question of the methods of expressing viscosity and viscosity-temperature relationships of lubricating oils had been discussed fully at the World Petroleum Congress, but there did

seem to have been a multiplicity of modifications of the Dean and Davis viscosity index system.

In conclusion, he would like to make some reference to standardization. There was no separate report this year on standardization, but there was, he knew, a great deal of work being done by sub-committees of the Institution in preparation for the new edition of "Standard Methods of Test." The question of international standardization was as urgent as ever. It has been discussed at the World Petroleum Congress, but, on looking through the report published in the Proceedings, he was not at all clear as to who was to take the first step after the Congress to put into force the recommendations which had been made. As was well known, in America there was the A.S.T.M., in England there were the B.S.I. and the I.P.T., in France there was the A.F.NOR., and in Germany there was the D.V.M., and there was also an official Italian Committee working on standard methods. A survey of the published work of all those societies showed a very striking difference between the methods used for some of the particular tests. For example, the A.S.T.M. and the I.P.T. had recently tentatively standardized different methods for gum determination, while the A.F.NOR. had circulated an entirely different procedure. For flash points there were the Cleveland, the Luchaire, the Marcusson and the Pensky-Martens apparatus; for colour there were the Lovibond, the Saybolt, the Dubosq, and so on.

He thought it did appear, therefore, that there was urgent need for closer co-operation between the various societies, and the hope was frequently expressed at the World Petroleum Congress that from a gathering such as that, where there was a large number of chemists from different countries, there would come some definite standardization of the more important methods of testing in the petroleum industry. He wondered whether someone could tell him what steps were being taken to bring that about.

Mr. A. Lloyd Eastlake said he was interested in anti-knock testing. He would like to know approximately how many engines (C.F.R.) there were in this country and, secondly, how they checked up with each other. He did not refer to inter-company checks, but all the companies checking up one against the other.

During the last six months in the United States there had been a monthly exchange of samples between about twenty different companies, including the Bureau of Standards, General Motors and Wankesha Motors, the samples being supplied by the various oil companies. The results of these tests had been rather surprising. Deviations of as much as three and four octanes from the average octane number were obtained. Every description of fuels had been

tested, including aircraft fuels down to tractor fuels, and an improvement was gradually being made. He thought that in the last series of tests, the average maximum deviation on five fuels was something like 2·6 octane numbers from the average, which was very good.

His own company had eight engines working and tried to keep within a deviation of one octane number, which at times was somewhat difficult to do.

Mr. C. H. Barton replied that there were probably not more than fifteen or twenty C.F.R. engines in this country. He could not express an official opinion as to what was considered satisfactory accuracy, but personally he was quite satisfied for general purposes if two different engines agreed within two octane numbers. Occasionally there were discrepancies amounting to four octane numbers. As a matter of fact, with one engine alone the repeatability was frequently not better than two. It had been found that a good deal of the difficulty was due to the fact that some of the cylinders had displaced cores in the head castings, which definitely affected the results. The laboratory temperatures in England were lower than those in the United States in the winter, but he did not think that would make any difference.

Mr. E. Thornton, expressing his own opinion, said he thought it ought to be stated for the benefit of those who compiled the reports that at least one man found them very, very helpful, and he preferred them uncensored, as they were now, so that he could form his own judgment as to what was good and what was bad.

Dr. A. E. Dunstan thought that on the present occasion members of the Institution would like to recognise and pay a tribute to the vast amount of good voluntary work that was done for the Institution. He was acquainted with a number of scientific and technical bodies and the way in which they worked, but he thought the Institution of Petroleum Technologists stood out prominently in the respect he had just mentioned. When one thought, for example, of the men who cheerfully year by year spent a large amount of time and trouble in compiling the Annual Reports, which really were regarded in the petroleum world as something particularly valuable, and when one thought of the considerable number of people who served on the various standardization committees and sub-committees, he thought it would be realised that the Institution owed a debt of gratitude to them for their output of sheer good voluntary work.

There was, however, one point made in the discussion to which he would like to refer, namely, the complaint, as he might call it, that there was not that measure of international agreement

in the matter of testing that was so much desired. The world to-day was suffering from an exaggerated economic nationalism. If anybody could tell him that the certain countries would drop their own peculiar methods of testing, or that, for example, Saybolt would be eliminated in favour of Redwood or Engler, he would be glad to hear it, but he was inclined for the next few years to despair of complete unanimity. There was, of course, a growing amount of co-operation. He knew personally that the A.S.T.M. had the very happiest relations with the testing bodies in this country, as would be realised by anybody who read the book on "Standard Tests." Also, he believed that his own appointment as Chairman of Committee D.2 was an indication on the part of the Americans that they were more than anxious to go, at any rate, halfway with this country in the good work in question. He thought that as far as Anglo-American testing was concerned, it was on really sound lines, and he did not see how it could go very much further. The position had been reached where there was a unanimity in the preponderating number of tests. The European situation was naturally very much more difficult. The stage had been reached that the I.S.A. should be a sort of international clearing house, and only a week ago he had met the Secretary of the I.S.A., who spoke in the highest terms of the work done in last year's Conference. Through the I.S.A. he thought there was reason to anticipate success, but not in the near future.

He would like to ask the members to join with him in an omnibus vote of thanks to the writers of the Annual Reports. (Applause.)

The Chairman said the members were indebted to all those who had contributed to the discussion. A number of valuable suggestions had been made by the various speakers, and they would be duly taken into consideration by the Abstract Sub-Committee.

Field Technology, Geology and General Sections.

Chairman: A. Beeby Thompson, O.B.E., M.I.Mech.E., M.Inst.M.M., F.G.S.

In opening the meeting **The Chairman,** Mr. A. Beeby Thompson, extended a hearty welcome to the overseas members who, sacrificing their well-earned leave, were attending these meetings to discuss the 1934 Reports on Progress of Naphthology. Their presence in this country afforded a unique opportunity for an exchange of views on oilfield problems concerning which they were pre-eminently competent to speak.

The reports to be discussed at this meeting were thirteen in number (a lucky augury) and they might conveniently be divided into three groups, namely, geological, technological and statistical. In the first group three papers dealt with the geology of petroleum and of oilfields and geophysics. The second group, including four regional papers, were mainly technological in character and covered a wide field, including transport and storage of oil. Statistical material comprised the third group.

Before referring to the contents of the reports, he felt quite sure he was voicing the wish of all members in expressing thanks to the authors for the pains they had taken to prepare articles of such high merit. A certain amount of overlapping was inevitable when branch papers of a general character were included, but this in no way detracted from their value, and to some extent accentuated interest by introducing conflicting views likely to stimulate discussion.

He considered that it would be invidious to select any paper for especial notice or any part of the contents for particular comment, and he would therefore confine himself to a brief reference to some of the more interesting statements with a view to giving a line to the spirited discussion which they were likely to excite.

Taking the papers in their natural order of sequence: first comes Prof. Illing's intriguing and fascinating paper on the Geology of Petroleum, full of highly contentious matter which might be profitably or unprofitably discussed for days. All will regret, he felt sure, the author's enforced absence from this meeting. Any field observations bearing on the genesis of oil would be welcomed, for the main fight still ranges around bio-chemical and thermal-dynamic theories of origin. A section of the paper likely to provoke comment is that which gives the reasons for a more general recognition that oil is often preserved in fissures, and that cracks, fissures and bedding planes are much

more important reservoirs of oil than has previously been generally accepted. The ascertained fact that the recoverable oil in some of the Persian limestone oilfields is mainly confined to minute fissures in the Asmari must have surprised many. The author also refers to the growing belief that the migration of oil is facilitated, if not caused, by fissures and crevices in disrupted strata on flexures.

Mr. Coomber, in a meritorious paper, summarises exhaustively the year's progress of oilfield geology in a pleasing style. Perhaps one of the most important points raised in this paper is the occurrence of mud volcanoes within the confines of proved oilfields and the probable influence of fissures on oil migration in many fields. The phenomenon to which Dr. Kugler has applied the term "sedimentary volcanism" is known in a number of fields and might profitably be debated. Worthy of record is the fact that since Mr. Coomber's paper was written, oil in commercial quantities has been struck on Bahrein Island and in Iraq, west of the Tigris; also a new strike of oil has occurred in the Steinberg area of the Vienna Basin.

Dr. Shaw's lucid and instructive paper on Geophysics emphasises the usefulness of selected geophysical surveys for prospecting, and the writer particularly refers to the increasing employment of the seismic reflection method. The value of geophysical methods in the process of development of oilfields is emphasised, and particularly the increasing use of electric coring, concerning which many present may have some first-hand information to communicate.

Mr. Ellis's comprehensive and informative article on drilling is so full of material likely to arouse discussion that it is difficult to put one's finger on those parts likely to attract most attention from members. The ingenious method of flowing wells to remove drill cuttings where mud control is either ineffective or detrimental to production will doubtless arouse interest. Pressure drilling is sure to stimulate discussion, as doubtless also will the statement that closed pressures rarely exceed the equivalent of a head of pure water. The causes for abnormal pressures or those far in excess of those due to a hydrostatic head is an appropriate subject for debate. The advocates of Diesel engines for drilling may have something to say about their displacement in Mexico due to their high cost in drilling 4000–5000 ft. wells. The field measures taken to ensure a supply of suitable water for circulation would interest many members. Many members would, he was sure, like to hear of the experience of those who had employed long, heavy drill collars to ensure verticality of holes.

The exceedingly valuable article by Messrs. Southwell and May dealing with Progress in Scientific Development is sure to lead

to comment from members directly associated with oilfield operations. A few points which at once attract notice are the references to the gas-saturation of oil and the peculiar conditions in East Texas; the doubts cast on the probability that oil is ever driven back down dip into the formation when gas caps are formed on oil pools; and the statement that white oil is considered a condensate of dome gas. The acid treatment of wells is likewise a subject at present receiving much attention and concerning which little is known outside a few fields.

Messrs. Satchell and Chapman treat the important subject of production technique in a thoroughly practical and exhaustive manner. The data given regarding intermittent displacement pumping cannot fail to raise questions from those operating under different conditions. The authors very properly draw attention to the risk of emulsion formation where contracted parts are used in production systems, and they refer to the increasing practice of using bottom-hole chokes and stop-cocking under these conditions. Many members have doubtless had field experience and any data they could give would, he felt convinced, be appreciated by many present. The methods of solving deep-well pumping problems are likely to induce many to recall difficulties with which they have been confronted and how they were partially or entirely surmounted.

Transportation and Storage is skilfully handled by Mr. Hartley in a very practical paper. One of the chief points which would probably appeal to members is the great stress placed by the author on the need of combating corrosion, and he correctly states that if corrosion can be prevented, the thickness of pipe lines can be adjusted to suit internal pressures with consequent considerable saving of capital expense. The author affirms that welded joints had superseded screwed as their cost is less and the results safer. It will, however, be noticed that Mr. Elias, in his Rumanian paper, says that only screwed joints were used for pipe lines in Rumania, with the exception of those designed for benzine transportation. Some might question the conclusion that screwed joints were always a source of trouble. Other matters which may raise queries are the cooling of Diesel engines, corrosion of pipes when embedded in oil sand or oil soaked ground, and the saving effected by the use of carbon dioxide in uncleaned oil tanks which are under repair by electrical welding. Perhaps some member with metallurgical knowledge can say something further about the chances of producing a non-corrosive pipe at an economic cost.

In the Branch papers many important questions are introduced but time admits of reference only to a few of the more provocative statements.

In the short Burma paper Mr. Abraham remarks that the use of cable tools is still retained for various reasons, notwithstanding the claims of the rotary to consideration, and he states that the dionic water tester has proved of considerable value. The author also records the interesting fact that heaving shales have been overcome by the use of mud with a minimum of free water.

Persia is briefly handled by Mr. Hall, who stresses the value of accurate measurement of reservoir conditions. Members will notice the surprising declaration that no well in Persia has ceased to flow through fall of pressure although some have gone to gas; also, that the removal of 26,000,000 tons of oil from one pool led to a pressure fall of only 6·7 lb. Such results he was satisfied could only be possible by a rational exploitation of the reservoir contents under a unit plan.

Mr. Elias had, he considered, contributed a remarkably interesting paper on Rumania to which it is difficult to do justice by a few remarks. Outstanding facts are the virtual displacement of all other systems of drilling by the modern rotary, the continued use of steam and the employment of a multi-tubular boiler from which the tubes can be removed intact for repairs or replacement; the completion of wells by a single column of casing and perforation with the gun perforator; the completion of 1800 metre wells in one month and drilling speeds of 300 metres per day, and the methods of dealing with paraffination troubles.

Trinidad developments are admirably described by Mr. Scott in a paper of engrossing interest. The following points in the paper may provoke some discussion if time admits. The verticality of wells is practically assured by concentration of weight on bottom by using heavy drill collars; drift of wells is almost invariably up-dip; deviation of wells can be corrected by the employment of a lipped bit, and difficulty in avoiding deflection when coring is in progress. The author also submits that in testing cements there is a tendency to over stress the importance of tensile strength, whereas permeability is the main factor for water exclusions. He also declares that the chamber valve has not proved successful in intermittent displacement lifts in Trinidad.

The last two papers, "Petroleum Literature" and "Oil Statistics," are mainly statements of facts and scarcely admit of discussion, but this fact in no wise lessens their importance and utility, and he was sure that all felt grateful to Miss Clarke and to Mr. Sell, our honoured Assistant Editor and Librarian, for undertaking the arduous and tedious task of making these valuable compilations.

Members were then invited to discuss the papers, and Mr. Ellis

who was largely responsible for the collection of the papers was asked to open the discussion.

The following papers* were presented for discussion :—

FIELD TECHNOLOGY.

"Drilling," by B. J. ELLIS.
"Progress in Scientific Development, Control and Production from Oil Field Reservoirs," by C. A. P. SOUTHWELL and C. J. MAY.
"Production Technique," by E. A. SATCHELL and S. H. CHAPMAN.
"Transportation and Storage," by A. C. HARTLEY.

REGIONAL REPORTS.

"Rumania," by G. ELIAS.
"Trinidad," by G. H. SCOTT.
"Persia," by P. de H. HALL.
"Burma and India," by W. E. V. ABRAHAM.

GEOLOGY.

"Geology of the Oilfields," by S. E. COOMBER.
"Geology of Petroleum," by V. C. ILLING.
"Geophysics," by H. SHAW.

GENERAL.

"Petroleum Literature," by W. S. E. CLARKE.
"Statistics," by G. SELL.

DISCUSSION.

Mr. B. J. Ellis said that there were one or two general remarks he desired to make. One of the ideas behind the arrangement for the present Summer Meeting was to give home members the privilege of hearing at first hand from members overseas of the technical progress and developments in their particular districts and any suggestions that they might make for rendering the Institution of greater value to them personally and to the oil industry in general. Some years ago he made an analysis of the membership of the Institution and found that the largest number of members in any one category were men interested in field work. It had been his effort since then to increase the amount of "Field's" matter in the Journal which represented to overseas members the chief return for their subscription. Members might have noticed that the "Field" abstracts had increased in number recently, and that the "Field" section of the "Progress of Naphthology" which was largely a summary of the abstracts that had come out during

* See pp. 524–662.

the year, was now considerably bigger than formerly. What was really needed, however, was information from the "Fields" both in the form of papers and in the form of notes on anything of interest. It had been suggested that there should be local representatives in various areas, but it would be very much better if every member abroad would constitute himself a local correspondent and report anything that might be of interest to other oil men. Records of drilling difficulties and fishing jobs encountered and overcome would be of much interest, as also would particulars of any special operations, such as pressure drilling or records of core recovery or any of the thousand and one things that go to make up the day's work on the Field. One was always inclined, when on the job, to think that what one knew oneself was known by everybody else, but that was definitely not the case. A thing that appeared quite ordinary to a man on the job was extraordinary to most other people, and short notes on almost any subjects would be welcome for publication. He thought that the trouble with all field men was that they were rather too modest. Their "opposite numbers" in the industry, judging from the amount of matter that was published, did not appear to be so. Seriously it was well worth while that these reports should be made, because of their real value to the Industry.

As to his own paper, on the subject of drilling, he would be happy to answer any questions, but he thought it was not necessary to give a summary of it. He particularly desired any suggestions from overseas members for the improvement of the Annual Report on this subject. Mr. Abraham had given him considerable assistance a couple of years ago when he started to analyse under suitable headings the mass of matter that had to be condensed into the Report, and Mr. Abraham, who was present, might have some views to put forward as to improvements in the compilation. What they were largely concerned with at this meeting was to know how the Institution could be of greater value to the overseas members and also itself obtain help from such members.

Mr. C. A. P. Southwell, when called upon by the Chairman to open the discussion on the "Progress of Naphthology" dealing with the scientific production development, desired, first of all, to express his appreciation and thanks to the President of the Institution for initiating the Summer Meeting which gave them the opportunity of discussing mutual problems with members of overseas staff who were on leave. It was a splendid innovation, the value and importance of which would increase from year to year.

Mr. Ellis had said that more co-operation was needed from their colleagues in the oilfields, but he felt sure that this would be forthcoming when it was more widely known that these meetings were

being held and that the opportunity was there for technical problems to be discussed. There were many difficulties in the way of obtaining satisfactory information from the various fields for mutual scientific discussion, but no doubt these would diminish in time.

He should also like to pay a tribute to Mr. Ellis for the stimulus which he had given to the provision of papers on fields matters. He did not wish to take up the time of members for, having been one of the editors of the "Progress of Naphthology," he felt that the time at their disposal could be employed much more satisfactorily by hearing the latest developments from overseas members. As the Chairman had asked him to open up the debate, however, he would throw out a subject for discussion.

At the recent World Petroleum Congress held in London, several papers were presented on the question of well instruments and their relationship to the economic production of oil which is the aim of these scientific deliberations. The development of instruments for well investigation—he referred more particularly to the bottom-hole sample taker and the bottom-hole pressure recorder—had been one of the more striking and rapid developments during recent years. The papers which had been read at the Congress had described the developments of this work which had taken place in the unit-operating fields in Persia, where conditions were such that these instruments could be used to great advantage.

The production control of fluids in limestone fields was simpler than in the majority of sand fields and the results discussed had been obtained under development conditions which were as ideal as could be found at the present time. The majority of sand field operators had, until very recently, taken up the attitude that bottom-hole investigations were not of practical and economic value in sand fields; he had never agreed with this point of view, even in Trinidad, where in some cases, however, the practical application of the results obtained by these investigations might be exceedingly difficult and of doubtful economic value. However, conditions differ widely in different fields, and that remains to be proved by experience.

Recently information had been made available regarding certain sand fields which indicated that this work was of considerable value if applied to structures produced under conditions of unit operation. He would ask, therefore, if any members from overseas had had experience in the use of bottom-hole instruments in sand fields, and, if so, if they would let the meeting have the benefit of their experience.

The second point he suggested for discussion was the relationship of such results to, and their effect on, well spacing, and in this

connection he would refer to the East Texas sand field as being a good example of what he had in mind. The East Texas sand field provided an example of a field in which the oil was not saturated with gas to the rock pressure. In order to examine these conditions it was necessary to use the bottom-hole sample taker and to undertake a survey of the field so that the saturation pressures at various points could be obtained. This work had been undertaken to a certain extent in East Texas and information was available.

Lindsly, whose solubility work in America was of considerable importance to technologists, had undertaken, he understood, a certain amount of investigation in this field. An examination of the results would perhaps show that, had this field been produced on a scientific basis with a thorough knowledge of the gas saturation conditions, the need for pumping equipment with its very great capital expenditure would have been considerably delayed and wells would have flowed under their own power for much longer periods.

The second point which he had mentioned was the question of well spacing. He had not the figures with him, but, as far as he could remember, the East Texas field was over 200 square miles in extent, and already in this area over 10,000 wells had been drilled, which would give one well to 12 acres; he was not certain of these figures, which were quoted from memory, but they would serve to illustrate the principle.

Generally speaking, a sand field in which the oil was undersaturated could be produced in much greater quantities per well than if the oil was saturated, and therefore, the obvious conclusion was that a much smaller number of wells would be sufficient to produce the oil which had been produced from the Texas field to date. One could say that this might have been produced with a quarter of the number, say, 2500, or some such figure. This was a very important point, and he would be glad to put this forward as a subject for discussion.

As far as limestone fields were concerned, the general well spacing was considerably greater, especially in those fields under unit control where spacing of one well to 300 acres was not unknown. This question of the relative use of the scientific investigation in sand and limestone fields brought to mind a point which he had been very interested to read in the June number of the JOURNAL (page 622), where a contribution by G. A. Scott was quoted, in which he said that "there has been in Trinidad extensive migration of oil, gas and water through crevices and fissures." The statement is qualified, however, by pointing out that such migration is not necessarily a characteristic of all sands or structures in Trinidad. He was interested to see this because it illustrated how important it was to undertake these surveys, as by their examination it might

be possible to see which sand fields were fissured—a matter of considerable importance in arranging development programmes based on knowledge of the movement of fluids so that the maximum possible of yield was obtained. He did not know whether this work was being undertaken in other oil spheres. What was being done in Russia, Venezuela and other large producing countries? It appeared that well spacing had increased year by year as more was known of the various reservoir conditions; he would ask, therefore, if members from overseas would give the members present the benefit of their experience on the questions which he had put forward.

Mr. C. E. Keep said that, with reference to the remark in Mr. Ellis's paper that the formation pressure at any depth rarely exceeds that of an equivalent head of pure water, it might be pointed out that there were some striking exceptions to that rule. One well with which he had recently been concerned could be balanced by a control pressure of 1800 lb. per sq. in. imposed on a column of mud weighing 90 lb. per cu. ft. That was at a depth of 5215 ft. If either the mud weight or the control pressure were allowed to fall, the formation would yield water. That, he thought, was sufficient evidence that in the well in question the rock pressure at 5215 ft. exceeded 5000 lb. per sq. in. In connection with the same well, it was noticed that when the applied pressure became superior to the rock pressure, water was squeezed out of the mud into the formation, the mud gaining weight and viscosity rapidly. On one occasion 94 lb. per cu. ft. mud pumped into the well against a bean pressure of 2100 lb. per sq. in. was returned to the mud ditch at a weight increasing to 96 and finally to 98 lb. per cu. ft.

With regard to drilling through high pressures generally, there was a need to develop a really heavy fluid which would completely control any possible well pressure and so almost entirely obviate the necessity to adopt pressure-drilling methods. A fluid with a specific gravity of about 3 would be of great use in that connection. With regard to that and other mud problems, such as the sealing off of formations and crevices, and the prevention of coagulation of mud fluid by heavily saline brines, he thought that petroleum technologists might well call for the assistance of colloid chemists who had devoted their careers to the study of problems of colloid chemistry. Much could be done by the technologist, but for the solving of many of the more difficult mud problems the co-operation of the experienced colloid chemist was necessary.

The method of closed-mud circulation in pressure drilling, mentioned in the first paper, carried the advantage of greatly reducing the demand thrown on the mud pumps, and it was presumably only a question of time until all the "snags" were

eradicated from that method and closed circulation became widely adopted in pressure drilling.

One of the most important advances made in rotary drilling of recent years had undoubtedly been the adoption of long drill collars of heavy stiff section. Both Mr. Ellis and Mr. Scott had referred to the fact that the concentration of the drilling weight at the bottom of the drilling string had been the most important single factor in effecting the improvement in straight-hole drilling that had been witnessed in recent years. That was also borne out by his own experience in India.

Turning to the second paper, he would like to ask if anyone present would explain the action of inhibitors in the acid treatment of limestone fields. There was no doubt that the addition to hydrochloric acid of many arsenic compounds or organic nitrogen or sulphur compounds greatly reduced the action of the acid on iron or steel, without appreciably affecting its action on calcareous rocks, but no chemical explanation of the inhibiting action had come to his notice.

The rotator pump, referred to in the third paper, appeared to have little advantage over the usual stationary electric motor. Counterbalancing of the well in the normal manner on pitman, band-wheel, or from the back end of the beam, was neither difficult not expensive. The focusing of attention on rod stretch, volumetric efficiency and critical pumping speeds had done much to improve beam-pumping methods. He could confirm from personal experience, however, that slow-speed long-stroke pumping need not always improve efficiency, besides necessitating heavier counterbalancing and heavier equipment throughout. The solution to many of the pumping problems experienced appeared to lie in the use of smaller diameter pumps with long or fairly long strokes.

The various new production devices, such as equipment for tubing wells under pressure, adjustable bottom-hole chokes, siphon and plunger lift, hydraulic and submerged electrical pumps, provided the production engineer with a greatly increased and at times an almost embarrassing selection of methods whereby to obtain the best results from his wells. Kick off units as now developed were a most valuable addition to direct gas-lift installations. He was sorry to note from Mr. Scott's paper on Trinidad, that in the gas-lift displacement method of pumping the use of a chamber valve had not proved a success, as the satisfactory development of such a valve was of very great importance. The loss of pressure in the annular space between the outer tubing and the macaroni reduced the efficiency of the method by roughly 50 per cent., and that served largely to limit the use of the method to wells of relatively shallow depth—say down to 2500 or 3000 ft.

Mr. A. Frank Dabell said that information of greater value would be contributed to these Summer Meetings if the branches could be advised beforehand of the subjects to be discussed.

In the matter of oil well cement he endorsed the declaration of the Chairman of the Trinidad Branch to the effect that the tensile strength factor was of minor importance compared with that of impermeability. The key to straight drilling was summed up in the title of a paper, "Gravity the Driller's Best Friend," read by Col. Hickling before the Trinidad Branch. He thought that the reported tendency for holes to run up dip merely arose from a natural tendency of the driller to increase the rate of drilling at the moment of leaving hard, steeply dipping rock, resulting in a corner of this rock being left at its lowest point and deflecting the drill up dip into the comparatively softer rock.

The paper by Mr. Southwell and his associate on the progress in scientific development and production from oil-field reservoirs deserved careful study, particularly that part referring to the movement of oil through sand bodies of varying density.

Efficient recovery from dense sands called for methods to increase the porosity of those sands. The increasing use of acids may attain this end.

The question of well spacing was usually viewed in this Institution only in its technical aspect, but the economic aspect cannot be ignored.

For instance, if one well could drain an area within a radius of 600 ft. in three years, was one justified in putting down two wells to capture the same quantity in two years?

Displacement pumping was showing to advantage in fields where little or no gas remained in the oil, but given a reasonable quantity straight gas-lift was holding its own.

A point of interest raised by Mr. Keep was the loss of liquid under pressure control drilling in the Punjab. This tended to emphasise the sealing value of mud.

The speaker believed that the control of high pressure in the future would be by the combined use of heavy mud and mechanical well head apparatus.

Captain D. Comins said that Mr. Ellis, in his paper, stated that: "The study of formation pressures which continued throughout the year showed that in most fields the gas, water and oil pressures to be expected were seldom in excess of the hydraulic head equivalent to the depth." He thought that was a loose statement. At what elevation in the reservoir was this equilibrium between the hydraulic head of the water and the reservoir pressure? Was it fresh water or salt water? From what point at the surface was the hydraulic head to be calculated? From the outcrop of the

reservoir rock or from ground level of the field itself as was often inferred ?

These points were never defined in the frequent references to this theory. To illustrate their importance, consider a reservoir of which the top of the dome was, say, 1000 ft. deep and oil-water level, say, 3000 ft. deep. Between the top of the dome and oil-water level there would only be an increase of about 670 lb./sq. in. in the oil pressure compared with an increase of about 870 lb./sq. in. in the hydraulic head if fresh water was meant and something of the order of 1000 lb./sq. in. if salt water was meant. Clearly, then, it was essential to specify the level in the reservoir at which such supposed equilibrium existed.

In any case he had not found the theory to hold good at any level. Although in some fields calculations based on equilibrium at oil-water level gave pressures of the right order, they could not be relied upon to do so. (Data from Persian fields were then quoted in support of this statement.)

In one field it was shown that the reservoir pressure in the dome was over 1000 lb./sq. in. greater than the hydraulic pressure there calculated from ground level, and at oil-water level was still about 800 lb./sq. in. higher.

He proposed to take this opportunity to state his own theory, which he believed to be original, regarding the limits of reservoir pressures. This was that reservoir pressures were controlled by the earth pressure at the weakest point in the structure—that was, he said, the point of least cover. He did not know of any cases where the reservoir pressure actually exceeded the earth pressure at the weakest point. He had noticed that, in fields where there were heavy seepages, the reservoir pressure usually closely approximated to the earth pressure at the point of least cover and was never less than about 60 per cent. of it. In fields, however, where there were no seepages the reservoir pressure might be very much less. He had only a limited amount of data on the subject, and would welcome further data from anyone interested.

His explanation of these observations was admittedly a speculative one and perhaps somewhat revolutionary. The usual conception of a cap-rock was often that of a rigid formation, not necessarily very thick, immediately overlying the oil-bearing series. Obviously such a cap-rock could no longer be competent once it was fractured by earth movements. In his opinion a competent cap-rock was plastic—*i.e.*, capable of movement and of transmitting pressure—and required to be of considerable thickness. When, as a result of erosion above such a cap-rock, earth pressure at the point of least cover to a structure was reduced below reservoir pressure, the plastic nature of the cap-rock allowed

seepages to start, so tending to equalise earth and reservoir pressure. As reservoir pressure was reduced by seepages, the plastic cap-rock tended to seal them off, so maintaining a rough equilibrium between earth and reservoir pressure and preventing the complete dissipation of the latter.

There was no time to discuss the whole problem of saturation pressures, but as mentioned in this year's Progress Report, the East Texas field was a very good example of their importance. In a paper last summer, Lindsly, of the U.S. Bureau of Mines, had described his work on bottom-hole samples in the East Texas fields, and had mentioned that his samples, which were collected at 1400 lb./sq. in., only began to evolve gas at about 750 lb./sq. in. The speaker pointed out that 750 lb./sq. in. was therefore the saturation pressure of the bottom-hole sample, and, further, the fact that producing gas-oil ratios of the field had since been reported to be fairly constant at 50 : 1 (per unit volume) indicated that the whole of the crude in the reservoir was fairly uniformly saturated to about that pressure.

Now on the East Texas Field the oil column was quite shallow —only about 200 ft. between the top of the dome and the oil-water level—so that there would be at least 550 lb./sq. in. difference in pressure between the saturation pressure of the crude and the dome pressure. Therefore a large daily production could be drawn from individual wells without fear of producing surplus gas—*i.e.*, gas from oil not produced.

Also no gas was being formed by gas coming out of solution from reservoir crude, nor would be formed unless reservoir pressures were reduced below 750 lb./sq. in. It followed, therefore, that the whole of the reservoir depletion had taken place at oil-water level. As long as production from the field was sufficiently restricted to allow this to continue, reservoir pressures could be maintained above the 750 lb./sq. in. critical pressure, as a rise of 200 ft. in oil-water level would not reduce reservoir pressures by more than about 30 lb./sq. in. or 40 lb./sq. in.

The point of importance to anybody operating the East Texas Field was that as long as reservoir pressures were maintained above 750 lb./sq. in., there would be no reduction in the dissolved gas energy available for lifting the crude to surface. It should be possible to maintain pressures by adequate restriction. By correct operation it should be possible to produce the whole of the oil in East Texas from a comparatively limited number of wells flowing naturally until the field was exhausted.

He asked whether any comprehensive surveys of saturation pressures, similar to those made on the Persian Fields, had been made elsewhere, as the results would be most interesting.

Again, it would be very interesting to get a pressure core-taker, for taking cores of reservoir rock under full reservoir pressure. It seemed to him that this would be of great value, because it would give positive information on the amount of drainage which actually takes place from porous limestone into fissures on reduction of reservoir saturation pressures. It was known that a fair amount of oil was left behind in the porous rock, and if a core could be brought up under full reservoir pressure, and it was possible to find out volumetrically the exact amount of oil it contained, one could say how much oil it had given up in the past, since production started. The importance of knowing that, was in the estimation and comparison of recoverable reserves under conditions of gas drive and of water drive. That subject, however, really needed a separate paper. Could anyone give the benefit of their experience in designing such an instrument or pressure core-taker ?

Mr. B. J. Ellis said that the sentence quoted by Capt. Comins from his paper allowed for exceptions to the general rough rule. He knew of cases in Burma and India where bottom-hole pressures were greater than the hydrostatic head, and was interested to learn details of the pressures in Persia. On the other hand, it was fairly obvious that the statement was generally true, as the bulk of drilling in the States was done with mud weighing somewhere about 70 lb. per cu. ft., and the number of blow-outs was comparatively small. The formation pressure could not, therefore, greatly exceed the equivalent head of water. Capt. Comins had suggested a pressure coretaker, but the speaker feared that there were many difficulties, not necessarily mechanical ones, to be overcome before such a tool could be perfected. One of them was that water from drilling mud tended to replace the oil in the core as the core was being cut, so that the original oil content would not be known even though the core was brought to the surface under the pressure at which it was taken. He had often found that a core which came up to the surface weeping with oil indicated an oil sand of very low productivity, whereas a core almost devoid of oil was frequently obtained from a highly productive oil sand.

Mr. W. E. V. Abraham said, in reply to Mr. Southwell, that bottom-hole pressure and bottom-hole sample takers arrived in Burma only two or three months ago, and that no actual results were yet available, though certain observations were being started. Probably next year something would be available. He was much interested in what had been said about abnormal pressures. He thought in some cases abnormal pressures deduced from surface observations might be a little fictitious, because of the presence of gas bubbles, but he had seen cases where this was not so and

where pressures were much greater than that of the equivalent head of water. He thought Capt. Comins' point, that the reservoir pressure was never likely to be greater than the equivalent "earth pressure," was a very good one, and he wondered whether one could also say that the original pressure in a reservoir was not likely to be less than the equivalent head of water? It seemed to him that in general the reservoir pressure would be somewhere between "equivalent water pressure" and "equivalent earth pressure," that is (speaking very roughly) between ½ lb. and 1 lb. to the foot of depth. He supposed the question of whether it tended to approximate to the "equivalent water head" or to the "equivalent earth head" depended largely on the competence of the rocks between the surface and the reservoir rock. If some or all of these beds were exceedingly competent they might presumably prevent or reduce continued "squeezing" of beds near the reservoir rock—and here reservoir pressure might tend to approximate to the "equivalent water head." If, on the other hand, the strata between the surface and the reservoir were of an incompetent type, and if close to the reservoir rock there existed, say, a bed of shale from which liquid could be expressed by "earth pressure" into the reservoir rock, the pressure in the reservoir would presumably tend to approximate to the "equivalent earth pressure." These remarks, of course, neglected any possible pressure effects due directly to gas genesis.

In connection with bottom-hole pressures, Mr. Southwell had gone on to discuss spacing problems. The speaker thought that spacing was the subject which they knew least in the oil business. The economic side was important, and it might be pointed out that if oil was worth x shillings a barrel, the correct spacing on any ordinary field would be different from the correct spacing with a price of 2 x per barrel. Nevertheless the scientific side of the problem was also of the greatest importance, and from this point of view what we chiefly wanted to know was the relationship between the number of wells drilled and the quantity of oil recovered. If this could be discovered the remainder was for the most part simple arithmetic. The time factor might also be of importance, and whether it was better to have one well draining a certain area in three years or two wells in a shorter period, on the assumption that the same quantity of oil would come out in each case, was an assumption which the speaker did not think was justified. He found it hard to believe that it would often happen in a sandstone field that two wells would produce only the same amount as one well. He thought it almost certain that in most sandstone fields, the greater the number of wells that were drilled, the greater the quantity of oil that would be recovered, other

producing conditions being the same. That did not mean, of course, that one should necessarily have exceedingly close spacing, because he did not think that two wells produced twice as much oil as one, and there came a point beyond which the additional quantity of oil recovered by closer spacing would not pay for (or yield a satisfactory profit on) the cost of the additional wells that would have to be drilled. An important incidental error to be guarded against in considering spacing problems is the assumption that where interference between wells can be detected the spacing must be too close. It would probably be less incorrect to formulate the general rule that where interference between wells cannot be detected the spacing must be too wide.

The problem of spacing was in practice complicated by another point—namely, the question of fissures. These fissures were well known in limestone fields, but the more one dealt with sandstone reservoirs the more one was impressed with the probable importance in them, too, of fissures or drainage channels of some kind with diameters of a different order altogether from those of the ordinary sandstone pore-spaces. It was a point on which it was rather hard to get evidence, but he would mention two lines of evidence which seemed to him to support the point of view that such channels existed. The first was in connection with the drilling of infillers. One had occasionally drilled a well quite close to an existing well, and found that the additional oil which the second well yielded was not as great as that by which the first well's yield appeared to have been lessened. That, at first sight, seemed to run counter to what he had just been urging in connection with spacing problems, but such cases were exceptional. They seemed to happen once in a while and could only be explained, the speaker thought, on the basis of there being some peculiar fissures, or drainage channels amounting to fissures, which had caused the oil to move in an abnormal way.

The second piece of evidence was in connection with mud. He had seen many experiments recently on the forcing of mud into sandstones in the laboratory, and it seemed very unlikely that mud as such (as opposed to water expressed from mud) could be forced through any ordinary sandstone. Yet most of them had seen examples of cases where mud had definitely disappeared as such in large quantities in sandstone fields. He did not see that there could be any explanation of that other than fissures of some kind or other.

Lastly, the speaker referred to the problem of the best general development policy for well marked sandstone structures. He first drew a picture of a fissured limestone reservoir in which, as development proceeds on the flanks, a continuously expanding

"gas-cap" is formed. He asked Capt. Comins whether it was not agreed that this gas displaced oil from the higher parts of the structure and that this oil was later produced by wells further down the flank.

Captain Comins agreed, subject to the proviso that a lot of oil would be left in the pore spaces (as opposed to the limestone fissures) high on the structure, and that this would not be able to move out of the pore spaces until pressure had declined considerably.

Mr. Abraham then considered the corresponding problem with a sandstone field, and said that it seemed to him very doubtful whether as gas migrated up to the top of a sandstone dome, making production of crestal oil difficult or impossible except at exceedingly high gas/oil ratios, we could be sure that the main part of the recoverable oil would move down dip at any appreciable rate. If this did not happen a policy of strictly marginal development might render unrecoverable—or recoverable only at wastefully high gas/oil ratios—some oil which, with proper well head control, might have been recovered by wells drilled on the higher parts of the structure at an early stage of development. The speaker did not, of course, suggest that, on the crestal parts of a well-marked sandstone structure of the type in which edge water does not encroach rapidly, spacing should ever be as close as on the more marginal parts, but he did suggest that on such a structure the drilling of a few crestal wells at an early stage might be justified, especially as they might later prove very useful for gas injection.

Mr. Harold Dabell, remarking that the travel of oil to a producing well, drawing from a sand, was commonly assumed to be dependent upon the degree of porosity of the rock, whether arising from grain dimensions or crevices, stated that he had recently visited an extensive outcrop of sand rock, a large area of which was completely impregnated with heavy oil or bitumen, the impregnation emanating from underneath the deposit.

Through the deposit ran "walls" of sand rock, several feet in width, carrying little or no impregnation by hydrocarbons and serving to divide the impregnated area up into regions or zones.

Casual inspection of these dividing factors showed them to be cemented by carbonate of lime; he assumed that this was the cause of the non-impregnation of these "walls," and it suggested that such obstructions could conceivably interfere with the travel of oil to a well, and thus reduce the potential productive area to something very much smaller than geological or technical investigations might assume to exist.

Mr. A. C. Hartley said that he had nothing to add to his

printed paper, but he was hoping that it would bring forth remarks from members present with regard to some of the points raised. With regard to the welding of pipe lines there had been a tendency in the past to help the welders by using a double-bell type of joint with an inner sleeve, so that, proceeding at the maximum rate, they need not fear producing any icicles, and they could get full penetration. Developments in the quality of electrodes and in the skill of the welder had apparently, during the past year or so, enabled the cheaper form of plain butt weld to be used. The tendency had been to run three runs of electrode instead of two, the speed had been greatly reduced, icicles had been avoided, and by building up a little on the outside wall compensation had been obtained for any lack of penetration which might result from too great care in avoiding icicles.

With regard to pumping stations, there appeared to be an increasing tendency to use Diesel engines, taking advantage of the improvements in economy and first cost that were being achieved by the Diesel engine manufacturers. One very important matter which the use of Diesel engines for pumping plants had brought forward was the question of torsional oscillations. In a close-coupled Diesel engine and electric generator not much trouble had been met with in the past. The maximum period of vibration of the system as a whole was extremely high, and only orders of $7\frac{1}{2}$ or 10 or higher had come into the range of the running speeds. But when the shaft was long and when centrifugal pumps were driven through speed-up gears the actual period of vibration of the system as a whole was greatly reduced, and there had been many cases where torsional oscillations had been imposed through excessive stress on the crank shaft of the engine. It was an insidious sort of thing which went on persistently on pipe-line pumping stations, and as the engine speeds crept up one soon got over a million reversals of stress, with inevitable failure. It had been the unfortunate experience of many people that an engine which had given no trouble for years suddenly gave out, the crank shafts, having just done their right amount of reversal, going off, one after the other.

The details around a pumping station had had a great deal of attention, particularly in Diesel engine stations. A lot of trouble with injection nozzles and lubrication troubles had been due to running the engine too cold, or trying to keep warm by throttling the amount of cooling water.

The other very great problem in pipe-line work was undoubtedly the question of corrosion. There had been a tendency in the past to cover lines the full length, independent of the soil through which they were going. As more knowledge was gained of the

condition of soil, the natural tendency was only to choke where the so-called heat spots were. A great deal of corrosion appeared to be due to electrolytic action, and the development which had taken place in closing a potential to the tube was of great interest, and it would be useful to hear experiences in that connection. That might be a means of reversing the tendency to cover the line the full length. Many useful devices had been developed for repairing and so forth, and any experiences would be welcome.

Mr. D. T. Jones, speaking with regard to Dr. Shaw's paper on geophysics, said that there were two points he desired to bring forward. One of them was rather important, namely, that in the past there had been a tendency in geophysics rather to lay too much stress on the accuracy of the methods. That had rather tended to spoil things for the science of geophysics.

Dr. Shaw had stated that under favourable conditions it was possible to estimate the depth of a reflecting surface with a probable accuracy of 2 metres in a depth of 1000 metres. That meant an accuracy of 0·2 per cent. In determining the depth of the horizon one was trying to find, the speaker thought that was claiming too much. Assuming that his timing were dead correct, and supposing that the overburden had an average velocity of about 4000 metres per second, it meant that he knew his average velocity to within about 8 metres per second. It might be that this happened under extremely favourable conditions, but in Persia, if they could get the average velocity in the overburden, say, to about 80 or 100 metres per second, they were very happy. He did not think he could claim this accuracy, and in general it was far too much to claim.

Another point he wished to bring out was in connection with the frequency of reflected waves. He had seen in papers published in the past—one in particular by Mr. Goldstone in the Congress Proceedings—that in seismograms one could see the reflected waves definitely as a train of waves, the frequency of which could be measured easily by the eye. He thought such seismograms must have been produced under very favourable conditions. In Persia, where conditions in the overburden are undoubtedly complicated, the reflected wave appears only as a single small pulse in the seismogram, often very difficult to detect. They were unable to recognise a train of waves, and the measurement of the frequency was therefore a difficult matter. With regard to measurements near the shot-point, they had not yet succeeded in recognising with certainty reflected waves at distances less than 4000 ft. Most of their work was done over the range from 5000 ft. to 10,000 ft. from the shot-point.

Then there was the question of instrument design. The speaker recalled that Mr. Rutherford, in a paper published some while ago, mentioned that there was a tendency to assume that electrical instruments were the only possible ones to use for reflection work. During the past year the speaker and his colleagues had used for reflection work the same instrument (the "Microid" seismograph, invented by Dr. J. H. Jones) as they had used for refraction shooting in the past, with very successful results. This instrument has been described before, and is obviously more akin to the mechanical type than to the electrical. Some weeks ago, however, the speaker had the opportunity of trying out some experimental models of various types of electrical seismographs, and he arranged matters so that an electrical instrument and a standard "Microid" seismograph produced simultaneous seismograms on the same record. Direct comparison could thus be made. He found that when using an electrical instrument of the induction type (which records the velocity of the ground displacement) the small, and sometimes almost imperceptible, pulses on the seismogram produced by the "Microid" seismograph were magnified to a considerable degree on that produced by the electrical, although the sensitivity of the two instruments to the waves of greater amplitude were of much the same order. The importance of this fact in reflection work is obvious.

Mr. E. Thornton mentioned the limitations to the full utilisation of welding in a refinery area owing to the danger from flame.

It would be inconvenient and uneconomical to render safe and free from gas any considerable area in a refinery in order to carry out a small piece of welding repair or alteration. This, however, was a very special case and was not meant to suggest any criticism of the valuable information with regard to welding in general that has been put forward.

Mr. C. A. P. Southwell, before the meeting closed, desired to take the opportunity of replying to several questions which had come up during discussion.

Mr. Dabell mentioned the fact that the tensile strength of the cement was not an important factor in oil well practice. He wished to take this opportunity of informing those members of the Institution from various fields that a British Standards Committee was sitting in conjunction with the Institution at the present time on oil well cement. A questionnaire had been formulated which was being sent out to the various field staffs, and it was only by accumulating data in this way that progress would be made. It was possible that the field staffs might not appreciate the value of such a questionnaire, but he would ask that on their return they would mention the fact that an effort was being made through

the Institution to collect sufficient data on this problem so that the committee could arrive at conclusions which would be of use to the industry itself.

Mr. Keep had mentioned the use of inhibitors where acid treatment of wells was practised, and he referred to the advantage of acid treatment in sand fields. Whilst the value of acid in limestone fields was very obvious, he could not see that it had an economic value in sandstone fields, where no lime constituent was present. With regard to Mr. Keep's question as to how an inhibitor worked, he had asked a well-known chemist the other day, and the answer was that the actual chemical actions could not be explained. They might be interested to know, however, that a satisfactory inhibitor was manufactured by one of the large chemical organisations.

He was very interested in Mr. Abraham's views regarding the location of wells in the crestal areas, and everyone would, he felt, have welcomed the opportunity of further discussion on this point, but he believed, however, that saturation pressure investigations would throw considerable light on the correct way of developing such a sand field.

In conclusion he would like to express his thanks to Mr. Beeby-Thompson for presiding over their discussions that afternoon.

The meeting terminated with a few remarks by the Chairman, who thanked all for their attendance and particularly those who had contributed to the valuable and instructive discussion which had resulted. He assured the overseas members that any contributions on local oil developments they could send to the Institution would always be gratefully received for incorporation in the JOURNAL.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

SIXTEENTH ANNUAL DINNER.

THE SIXTEENTH ANNUAL DINNER of the Institution of Petroleum Technologists was held at the Park Lane Hotel, London, on Friday, June 29th, 1934, Mr. Thomas Dewhurst, President, occupying the chair.

"The King."

The Toast of "The King," proposed by the President, was received with musical honours.

Presentation of the Redwood Medal.

The President: The Redwood Medal was instituted in 1923 in memory of Sir Boverton Redwood, the greatest petroleum technologist of all time, and the Founder and the first President of the Institution. The original conditions of award contained no restrictions as to nationality or membership of the Institution, the medal being awarded to the author of the paper of the greatest merit presented to the Institution during two consecutive sessions, provided always that the paper attained a standard sufficiently high to justify the award. The medal was valued so highly by the Council that under these conditions it was awarded only on three occasions, and then only for very valuable and outstanding contributions to petroleum technology. But in course of time the Council decided to place a much higher value on the award, and to confer it only on petroleum technologists of outstanding eminence. A very important consideration which greatly enhances the value of the award is that it is not conferred annually nor periodically, but only on those rare occasions when the Council is satisfied that there is a recipient of the stamp of the illustrious petroleum technologist in whose honour the medal was struck. Indeed, the medal has been conferred only once under these stringent conditions of award. Nevertheless, the Awards Committee and the Council had no doubts whatever in deciding unanimously that the medal should be awarded to Dr. David White, the distinguished doyen of the United States Geological Survey.

Dr. White entered the United States Geological Survey in 1886, served as Chief Geologist from 1912 to 1922, and is still with that organisation. During his ten-year term as Chief Geologist, and also during his administration of the oil and gas work of the survey for many years, he initiated numerous investigations concerning the geology of petroleum, its development and its conservation. The most notable of these investigations are the following :—

(i.) Investigations which yielded valuable data in regard to temperatures in deep bore-holes and mines.

(ii.) Investigations bearing on the damage caused by water in a number of oil-bearing territories.

(iii.) Field investigations into the vast deposits of oil shales in Colorado, Utah and Wyoming.

(iv) Early in the World War the United States Geological Survey directed its attention to the vital question of increasing the country's petroleum supplies, and every available oil geologist on the survey was assigned to work under Dr. White's supervision in known and prospective petroleum regions.

(v.) Estimates of the petroleum resources of the United States were prepared from time to time during the period 1916–1922, and in 1919–1920 an estimate of the petroleum resources of the world was prepared by Mr. Eugene Stebinger working under Dr. White's supervision.

(vi.) Dr. White is well known as the originator of the carbon-ratio hypothesis, his studies in the Appalachian and Mid-Continent regions having led him to suspect the existence of a significant relationship between the coal deposits and the occurrences of oil and gas. Whatever be the ultimate fate of that hypothesis, it has been one of those stimulating and even vitalising conceptions which lead to the inception of new research and to further discoveries.

(vii.) Dr. White is, of course, famous for his original researches in paleo-botany.

Many officers of the United States Geological Survey have from time to time passed into the service of the petroleum industry, which has benefited by the experience of those officers, gained by their association with Dr. White.

There is one feature of Dr. White's career which is worthy of mention. I understand that on many occasions he has received tempting offers to devote himself solely to economic work, but that he has always declined these, as he felt it to be his duty to devote his life to fundamental original work and research.

Notwithstanding the large amount of research work carried out by Dr. White, he has borne his share of heavy administrative and other duties. During his term as Chairman of the Division of Geology and Geography of the National Research Council he was a guiding spirit in outlining a programme of fundamental research in petroleum that was undertaken by the American Petroleum Institute, with the advice and assistance of the Central Petroleum Committee of the National Research Council. In addition, in 1925, his counsel aided in obtaining from John D. Rockefeller $250,000, and, in 1926, a like amount from the Universal Oil Products Co., for research in petroleum geology. This half million dollars was made available for supporting a

five-year programme of research, which was large in magnitude and wide in scope. Dr. White not only served as a member of the Central Petroleum Committee for the general guidance of the investigations, but he also served as director or adviser for some of the individual projects.

Dr. White is a prophet with honour in his own country. In 1931 he received from the National Academy of Sciences the Mary Clark Thompson gold medal for distinguished services in palæontology, and he was elected to honorary membership of the Geological Society of Belgium, and more recently of the Geological Society of China. He received the honorary degree of Doctor of Science in 1924 from the Universities of Cincinnati and Rochester, and in 1925 from Williams College. He is a past-President of the Geological Society of America, a past Vice-President of the National Academy of Sciences, and he served for many years as its Home Secretary. He also served as Chairman of the Division of Geology and Geography of the National Research Council. On account of his distinguished services in the field of economic geology he was awarded, in 1931, the Penrose Medal by the Society of Economic Geologists, and fifteen years ago he was elected to Honorary Membership of the American Association of Petroleum Geologists. These awards testify to the honour in which Dr. White is held by his fellow-workers in his own and other countries, and by awarding him the Redwood Medal all British petroleum technologists are proud to confer on him the highest honour which it is in their power to bestow. I would add that at the Council meeting held on the 19th inst. Dr. White was elected an Honorary Member of this Institution.

Dr. White has expressed his great regret at his inability to undertake the journey from Washington, and I am sure that we all share that regret. It was hoped that His Excellency the Ambassador of the United States of America would be able to accept the medal on behalf of Dr. White, but his inability to be with us intensifies, if that were possible, the welcome which we extend to Mr. Herschel Johnson, the First Secretary of the Embassy of the United States. I would assure Mr. Herschel Johnson that it is particularly fitting that the Redwood Medal of this Institution should be awarded to one of his countrymen, as, apart from the United Kingdom, this Institution has more members in the United States than in any other country. We also have members in about fifty countries, and petroleum technologists all over the world are deeply indebted to their fellow-workers in the United States. Moreover, acceptance of the medal by you, Sir, will strengthen the friendly bonds which exist between American and British petroleum technologists. I therefore invite you to accept the Redwood Medal on behalf

of Dr. David White and to transmit it to him with the Institution's wishes that the sunset years may glow with the memories of a long life's work well done.

Mr. Herschel Johnson (First Secretary, Embassy of the United States of America), in accepting the medal, said: I should like first of all to express my personal appreciation of the invitation you have given me to be present at this meeting, and my pleasure at the opportunity which it affords of meeting so distinguished a group of British scientists. Work such as that sponsored and fostered by the Institution of Petroleum Technologists seems to me to offer one of the greatest possible fields for furthering friendly and profitable international relations, because by its very nature it has no national boundaries, and brings together enlightened and well-informed individuals of different countries, who are bound by a common intellectual interest. It is most gratifying that you have found one of my compatriots worthy of the high honour you are now conferring, and I feel certain that it must be a great disappointment to Dr. White that he is unable to be present in person to receive the medal and to express to you his appreciation.

Immediately on learning that he was to receive the award of the Redwood Medal, Dr. David White cabled: "Profoundly appreciate distinguished honour conferred by Institution." He then wrote and explained that on account of his state of health he was hardly strong enough to undertake the journey to England, much as he would like to meet leading British petroleum technologists and greatly as he would appreciate the intellectual stimulus of a visit to the headquarters of the Institution.

Dr. David White has, therefore, requested me, in accepting the medal, to convey to you the following message:—

> Mr. President, Members and Guests,—The honour you bestow on me is eminently distinguished by the name of the Founder and first President of your Institution, a scholar pre-eminent for his life-long labours and learning fruitful to mankind. I wish I were able to express to you in person the very deep pride and pleasure I feel in receiving from your hands the Redwood Award and my sense of the high recognition you thereby pay to all my American colleagues and friends. With them I share the genial warmth of your cherished greetings."

Ambassador Bingham has asked me to express to you his deep regret that a previous engagement has made it impossible for him to accept your invitation. The Ambassador is deeply cognisant of the honour which has been conferred upon our fellow citizen, and shares the high esteem I feel for your organisation.

"The Institution of Petroleum Technologists."

Mr. G. C. Whigham: There falls to me the great honour and pleasure of proposing the toast of the "Institution of Petroleum Technologists." The Institution has done magnificent work in countless directions since its foundation. For one thing, it has helped towards greater harmony and greater co-operation between the various branches of technology which go to make up the technical side of the oil industry. The good work has not stopped there, for it has also brought about greater harmony and greater co-operation between technologists of all countries, and this in its turn has helped to bring about greater harmony and greater co-operation within the industry itself, in the realms of production, refining, distribution, marketing and even general policy.

I remember the time when there was the utmost reticence on the part of oil concerns as to their operating methods. Every little idea, every little trick, every little gadget was jealously guarded from prying eyes. But the brotherhood of technology has largely changed all that, to the undoubted advantage of the oil industry as a whole, and the Institution of Petroleum Technologists has had its full share in bringing about this very advantageous change. As your President has already said, it is particularly pleasing to us Britishers here to-night that this harmony between technologists of all countries should have been exemplified in the award of the Redwood Medal by your Council to Dr. David White. (Hear, hear.) I have not had the honour of meeting Dr. White, but knowing as I do the volume of ability, genius and brilliance which is comprised within the membership of this Institution, I conclude that Dr. David White must have been a very worthy recipient of the honour which he has received.

Not the least important of the functions of this Institution is the encouragement and the assistance which it extends to students and to those aspiring technologists who are to become the technical brains and sinews of the oil industry of the future.

The past year has been a very busy and, I am sure, a very fruitful one. The World Petroleum Congress, so ably presided over by your President and so ably seconded by Mr. Kewley, brought together in this city technologists of all branches, all grades and all nationalities, and the results of their joint labours and deliberations cannot fail to have been of the greatest interest and value, not only to the science of petroleum technology, but to the oil industry as a whole. Many problems of the first importance were discussed and many papers of great value were contributed on a host of different subjects. These papers have now, I understand, been published in book form, and they constitute a record

of the work and labours of the Congress which will be of lasting interest and value.

As some institutions go, your Institution is but a stripling, but I regard it as a very virile and robust stripling. In its comparatively short life it has achieved great things, and its activities are now world wide.

So much for the past work and history of the Institution, but what of the future? I am no technologist and I am no prophet, but I hold very definite theories as to the past and future of oil, and with the latter are bound up the future work and welfare of this Institution. I have from time to time discussed these theories with your President, and I am left with the impression that these theories of mine are insufficiently materialistic to enlist his entire support. Nevertheless, I am going to take the opportunity which he has, perhaps unwittingly, given me of letting these theories loose on you.

There used at one time, I believe, to be an acute difference of opinion between geologists who favoured the organic theory of the origin of oil and those who favoured the inorganic theory. The latter theory, I understand, has now more or less suffered the fate of the Dodo, but be that as it may, my theory is that the Almighty has very definitely and very designedly caused the petroleum deposits of the world to exist for the benefit of mankind, just as He said, "Let there be coal," and there was coal. The winning of coal and its applications to men's uses has required—up to now, at all events—much less skill than the production of that varied range of products which can be secured from petroleum. Coal, however, has been suited to man's uses, man's knowledge and man's skill during the Coal Age. As man's skill and his requirements progressed, the Almighty had a new raw material in reserve. At first it was found at shallow depths, and served very limited uses. As skill in the invention, manufacture and use of drilling appliances advanced, the deeper reserves were there for the taking, and as chemical and engineering skill progresses so the range of products procurable from petroleum ever widens and changes to meet the ever-growing and ever-changing requirements of civilisation. In my view, nothing is haphazard or due to mere chance chemical or organic changes beneath the crust or on the surface of this old globe. Everything advances in a predestined and orderly manner, and the Oil Age overlaps the Coal Age, just as some day a new age will overlap the Oil Age. But Dame Coal, like many other good ladies, refuses to believe that the flowers of youth are gone never to return (Laughter), and the reare not lacking those quack and expensive remedies which claim the ability to restore the bloom of youth. These, I fear, will be doomed to

the failure which always attends attempts to defeat the dictates of Divine Providence, and John Bull, like the admirers of these other good ladies perhaps, will pay and pay and pay for his infatuation.

Nor is the advance in oil technology haphazard. It is in line, as I have said, with the ever-growing and ever-changing requirements of mankind—from which I conclude that you, gentlemen, are as much of divine origin as the coal and the oil deposits of this earth. The Coal Age passes, the Oil Age is advancing, and in the light of present-day knowledge, we can say with assurance that the Oil Age is still in its adolescent stage and that the science of petroleum technology is still in its infancy. Long before oil has reached its old age you technologists will have found ways and means of administering the necessary monkey glands to keep Old Man Oil robust and to re-energise his old age.

Holding these views as I do, I never miss a meal or a good night's sleep when I read in the papers of some miraculous discovery which is going to supplant natural petroleum. You can read of these things almost every month. I have met several of these miracle mongers. I remember one very plausible gentleman whose methods rather savoured of those of Dick Turpin. He had a wonderful invention which was going to provide us with synthetic petroleum at curiously low costs and on a perfectly commercial basis, but he was not prepared to disclose his secret unless we paid him a large round, fat sum in advance. If we refused to pay the sum, then he was going to blow our industry sky-high. Well, we are still just carrying on.

I remember another gentleman whose manner was rather less brusque and certainly more ingenious. He had discovered a powder which, when you added it to water, turned the water into the very best petrol. He, also, strangely enough, was not prepared to disclose the nature of his powder. Some of you have probably heard this story, but in case you have not all heard it I will risk it. He was quite prepared to give a demonstration of the miracle before experts, so it was duly arranged that he should do so. He arrived before the body of experts with his paraphernalia, which consisted of a glass vessel, a small cloth and a bag of powder. The vessel was filled with water, then the cloth was put over the vessel, and he proceeded, as he said, to add the powder. In a few seconds the cloth was removed and—lo and behold !—the water had become petrol. His *modus operandi*, I am told, was something as follows. Under one arm he had an empty rubber ball with a tube down his arm, and under the other arm he had a rubber ball filled with petrol, also fitted with a tube down the other arm. When pressure was applied to the second ball the petrol would

flow out, so when he was supposed to be putting powder into the glass vessel he put the end of the first tube into the vessel, having previously deflated the ball, and then released the pressure, sucking the water out of the vessel. Having done that, he inserted the other tube, applied the necessary pressure, and—hey presto !—there was the petrol.

I do not believe in miracles, but we had better be careful, because what appears to us laymen as miracles to-day, through the agency of you scientists are very apt to become scientific facts to-morrow. But of this I am sure : that no other substance will supplant natural petroleum until Nature has ordained that the supplies of that product are not sufficient for the world's needs.

On the basis of this theory I see a very long, prosperous and useful career before the Institution of Petroleum Technologists, and I have much pleasure in asking you to drink to its future, and with the toast I couple the name of its President. I have known Mr. Dewhurst and have been associated with him in business for nearly a quarter of a century, and I can speak with first-rate assurance and knowledge as to his great ability as a practical geologist. The fact that you have chosen him as your President gives expression to the very high opinion you have of his scientific and organising ability. If confirmation of your good judgment were required, his handling of the World Petroleum Congress and the work which he has done for your Institution during his Presidential year would amply afford it. He is a man of great purpose, much to be trusted and withal a very genial companion and a much-respected colleague—qualities not always to be found in one President, or, for that matter, in one individual. Gentlemen, I give you the toast of the Institution of Petroleum Technologists, coupled with the name of Mr. Dewhurst.

The President, in reply, thanked Mr. Whigham for the generous terms in which he had proposed the health of the Institution, and thanked all present for their kindly acceptance of the toast. He referred to Mr. Whigham's very long association with petroleum and to his very close connection with each and every technological aspect of the industry.

The President then reviewed briefly the activities of the Institution during the past year and paid a tribute to the wonderful team work of the officers, staff and members. On December 31st last the membership was 1250 and is now 1303, and he doubted if any other society or institution showed a corresponding rate of growth during the period. He also referred to the great importance which Council attached to research in petroleum technology, and pointed out that the Research Fund Committee welcomed applications for grants in aid of suitable items of research. The Students

Section had had a most successful session, the London Branch having carried through an unusually interesting programme of meetings, the final meeting being devoted to an important address by Mr. T. C. J. Burgess on "The Economics of the Petroleum Industry." He made only brief references to the Branches, the Journal and the Benevolent Fund, as he expected that Dr. Dunstan would deal more fully with these aspects of their activities.

Mr. Dewhurst then suggested that the general Press of this country did not appear fully to have appreciated the importance of the World Petroleum Congress, although, following the introduction of the Government's Petroleum Production Bill, they had engaged in much interesting speculation regarding the prospects of oil being found in this country. He stated that petroleum technologists had always urged that there should be as few legal and other obstacles as possible to the search for petroleum and to the sound development of oilfields, and claimed that the Institution had published much valuable material which would be most helpful in the discovery and the subsequent sound development of oil deposits of any country. He finally issued a *caveat* against any premature assumption that this country is full of glittering prizes for those with stout hearts and sharp bits.

The President then referred to the artificial restrictions and difficulties which prevented "Homo Economicus" from attaining in his economic affairs that state of balance or stable equilibrium which is displayed everywhere throughout Nature and suggested that natural conditions should constitute the foundations of economic architecture. In recent years there had been several attempts to regulate the world's production of certain essential products, and in regard to petroleum it might be found possible in future to pro-rate production on the basis of the best estimates of the proved petroleum resources of producing countries.

Mr. Dewhurst then referred to the tendency for technologists to participate to a large and increasing degree in the original scientific work and research which formerly was carried out almost entirely by the academic scientist.

The President then expressed his great faith in the future of the Institution, but pointed out that no institution could live without progress and therefore that it would be necessary to go boldly forward and not to be deterred by the difficulties which beset the initiation and development of new projects. Although their achievements would always fall short of their ideals, he felt that a review of their activities during the past twelve months showed that the Institution was making satisfactory progress.

"Our Guests and Overseas Members."

Dr. A. E. Dunstan, in proposing the toast, said that this was the first time there had been even half a toast to the members from overseas, and it was with particular pleasure that we welcomed them, and specially those who represented the branches.

He had had the good fortune to assist in the formation of two of those branches and looked forward to new ones. They served to foster comradeship, to provide platforms for papers, and to give point to our motto, "*Conjunctione potiores.*"

Coupled with the toast was the name of Mr. W. E. V. Abraham, and he gathered that this was done to impress upon him the urgency of forming a Burmah Branch.

A matter particularly dear to him was the Benevolent Fund, to which the Persian and Trinidad Branches had made handsome contributions. That was an example which all members should follow.

Speaking of the JOURNAL, he said that the editorial staff welcomed criticisms and suggestions as to how it could be made more and more useful. In this connection he would like to commend the valuable and important work of his colleagues, Mr. G. Sell, Dr. F. H. Garner, Mr. W. H. Thomas and all the Abstractors and Contributors to the Annual Progress Reports.

Dr. Dunstan then referred to messages of regret that had been received from guests who were unable to be present. There was, however, no lack of distinguished guests present, and to mention them all would be a work of supererogation.

He particularly welcomed Col. L. Pineau, whose name he desired to couple with the toast, and he also asked Mr. Herschel Johnson to accept their thanks for his presence.

The name of Mr. J. D. Cassels was also coupled with the toast, and to him he extended a cordial welcome.

Mr. W. E. V. Abraham, in reply, said that as one of the overseas members he particularly welcomed the opportunity of being able to be present at the Annual Dinner and also at the meeting which had been held on that and the previous day.

He thought that the overseas members would wish him to say how appropriate it was that the toast should be proposed by Dr. Dunstan, who, as Editor of the JOURNAL, had been mainly responsible for the chief link between the overseas members and the main body. He also desired to thank those who were responsible for the Abstracts, which were so helpful in enabling those resident abroad to keep abreast of current developments.

With regard to the formation of a branch in Burma, he had reason to believe that the heads of the various oil companies in that country shared the view that this was possible, and he hoped that before next year such a branch would be in existence.

Colonel Pineau, in reply, said: "The last time I was in your company was when I attended the meetings of the World Petroleum Congress, and I remember telling you at that time that you might rest assured that the representatives of France would most heartily co-operate with you in the great work of co-ordination of which we were then celebrating the creation. I believe, gentlemen, that since then we have shown that we really meant to keep our promise. During their sessions, the members of the Association Française de Normalisation have largely been inspired by the standards already adopted by your Institution and by the American Society for Testing Materials. In fact, they have accepted them in many cases without the least modification. I am sure that I need not insist upon the necessity of developing still further this community of spirit amongst our technologists and of realising it in as extensive and complete a form as possible.

"Gentlemen, my country has shown to how great an extent it was interested by the efforts of Great Britain in sending to the World Petroleum Congress one of the most important foreign delegations. It was most happy on that occasion to co-operate with you on an international plan. Since then its technologists have given proof of their desire to maintain the closest contact with you. Will you therefore allow me to express the hope that the community of spirit already existing between our two countries may be extended and very rapidly reach the same degree of perfection as that already attained by our technologists in the matter of oil production ?"

Mr. J. D. Cassels, K.C., M.P., also in reply, said: "This is a very remarkable assembly. I have never seen such a cheerful lot of faces for many a long day. You must have left all the cares you possess outside when you can to this gathering.

"There are some cares outside. Somebody mentioned taxation a few moments ago. I know of no rule whereby you petroleum technologists are immune from taxation. How it is that you are so cheerful I am unable to understand ; it must be because there is so much money in oil and you get such a large share of it that you can afford to face the burdens of the world with a smile. Some reference was made to the Bill which is before Parliament. I can tell you the object of that Bill : it is to stop people digging in their back gardens for petrol. (Laughter.) We want the petrol to come from overseas. We do not want to find it here ; it would be too easy to get. We like to know that there is a great Institution like yours, whose members are concerned in the various activities which apply to the production of the stuff that we put into our cars."

REVIEWS.

THE DESIGN AND CONSTRUCTION OF HIGH PRESSURE CHEMICAL PLANT. By Harold Tongue. London: Chapman and Hall, 1934. Pp. ix.+420. £1 10s. net.

This book fulfils a want that has been evident for some time. It is well produced and profusely illustrated. The author has been intimately concerned with high pressure apparatus and design at the Chemical Research Laboratory, Teddington, for some time, and is thus well fitted to give an authoritative account of this very important technique which has progressed so rapidly during recent years. The book deals in detail with such matters as high pressure gas compressors, design of pressure vessels and autoclaves, high pressure pipes and fittings, and also with the selection and properties of steels suitable for service under stress at elevated temperatures. Admirable photographs and descriptions of plant installed at the Leuna works of the I. G. Farbenindustrie, and at the Billingham factory of Imperial Chemical Industries, Ltd., indicate the gigantic scale of the high pressure operations conducted by these world famous chemical concerns, and are adequate proof that catalytic high pressure processes are now fully established (quite a number on an economic basis) and have long passed the experimental stage. Despite the sceptic these processes have come to stay.

Mr. Tongue's book represents the first attempt to give, in the English language, an account of developments in the high pressure field, and therefore criticism is difficult. It is, however, rather surprising to find that so very little mention is made concerning high pressure liquid level gauges and level indicators; neither the well-known Klinger gauges, nor the pneumatic type level indicators used on large high pressure forgings are mentioned. On the other hand, most other types of fittings such as valves, pressure gauges and high pressure gas flowmeters are fully described. The author also omits to give the reason why high pressure plants designed for use with gases containing carbon monoxide—*e.g.*, water gas—are often lined with high melting point non-ferrous alloys. The dangers of carbonyl formation, both from the point of view of rapid catalyst poisoning and plant deterioration, are not discussed. Furthermore, the index of the book contains no reference to corrosion, a matter of vital importance in all coal and oil hydrogenation plants, and the design of large ammonia and methanol converters is only very briefly mentioned.

One is therefore left with the impression that the usefulness of the book would have been increased somewhat if subjects such as these had been considered in greater detail, and if some of the lengthy passages dealing with the preparation and purification of industrial gases, which hardly come within the scope of the title, had been reduced.

Despite these omissions, and there must necessarily be some omissions in such an ambitious book as this, which deals with a subject on which those who have the greatest experience publish so little, the volume is of great value, and should be read by all who are interested in high pressure reactions.

D. A. HOWES.

DEUTSCHES ERDÖL: II. FOLGE. Von A. Moos, H. Steinbrecher und O. Stutzer. Stuttgart: Verlag von F. Enke, 1934. Pp. 98, 8 abbildung. Rm. 9·80.

The main part of this second volume on German oil is occupied by a paper by Dr. August Moos, entitled "The Oil Wells in the Northern Part of the Rhine Rift Valley near Brücksal, 1921-1926." This paper is of especial interest at the present time in view of the Baden Government's recent decision to encourage further exploration in the State. Dr. Moos deals in detail with the stratigraphical succession, the tectonics and oil indications as disclosed by the logs of some eleven wells drilled by Dr. Anton Raky, to whom the author is indebted for permission to publish the results.

The higher part of the succession consists of Alluvium and Pliocene amounting to some 180 metres; below that there is a break, the Miocene being absent, followed by a thick development of Oligocene amounting to over 550 m. The lowest Tertiary is represented by a little over 100 metres of Eocene. This Tertiary succession is characterised by numerous intercalations of terrestrial and especially fresh water beds. Below the Eocene occurs another strong unconformity and the deeper wells have gone direct from Eocene to Jurassic (Middle Dogger), or where beds have been cut out by faults to Lower Dogger, Muschelkalk, and the Upper Part of the Bunter sandstone. The tectonic structure disclosed is typical troughfaulting of the Rhine Rift Valley. Considerable evidence of oil was obtained in these wells. The main Tertiary petroliferous horizons were the Meletta Beds (Middle Oligocene) and the green Limnea Marls (Upper Oligocene). Strong indications of oil were met with in the Muschelkalk and Bunter. An interesting point is that the Pechelbronn beds so richly petroliferous in Alsace show here a completely non-petroliferous facies.

As regards the origin of the oil Dr. Moos, though a staunch supporter of the secondary nature of the Hannoverian oil occurrences, inclines to the view that the Eocene Limnea Marls may represent a source rock, although, as he points out, this is against the commonly held view that oil only originates in marine or esturine deposits. This paper can be thoroughly recommended to anyone wishing information on this district, either from the purely geological or from the oil point of view.

Turning now to the two short papers, the first by Prof. Dr. H. Steinbrecher and Prof. Dr. O. Stutzer, the second by Prof. Dr. O. Stutzer entitled "Chemical Investigation of German Oils and their Relationship to Depth and Geological Formation" and "What Is Your Opinion? Does the Mother Substance of the Oil Produced in Hannover Lie in the Mesozoic or Does the Oil Originate in the Zechstein?" respectively.

The first paper is devoted to a critical examination of 29 different samples of oil from the various Hannover fields which the authors obtained from the various companies. The properties determined were specific gravity, viscosity, distillation ranges, paraffin content and asphalt content. The results are set out in tabular form and numerous graphical diagrams given in which the properties are plotted against depth. The two main conclusions

drawn by the authors are : (*a*) That the oils from any given geological horizon show a progressive lessening of specific gravity with increase of depth. (*b*) That there is a sharp line of demarcation between the oils from the Lower Dogger and older formations, on the one hand, and those from the Upper Dogger and younger formations on the other, the former being the light oils and the latter the heavy. The authors confine themselves to facts and do not indulge in speculations as to the ultimate source of the oil. It is perhaps a pity, in view of the controversy on the origin of German oils, that the authors did not include in their oil samples a few from the Zechstein.

Finally, in his paper, Prof. Dr. O. Stutzer gives a quite unique collection of opinions on the question of the origin of German oil. He first gives what are, in his opinion, the pros and cons of migration from pre-salt formations.

In favour of migration from pre-salt formations :—

(*a*) The multiplicity of oil horizons in different formations in the same area.

(*b*) Many vertically bedded oil horizons are now covered by unconformable younger beds.

(*c*) In the Wietze field in the oil horizons of the higher part the oil surface (salt water surface) approximates everywhere to the same level.

(*d*) In the Lower Dogger of Oberg the oil is in sheet sands. Lenticular sandy intercalations carry no oil.

Against migration from pre-salt formations :—

(*a*) Lack of open fissures.

(*b*) The apparent lack of oil in the Bunter.

(*c*) The carrying of oil by large clay iron nodules in the Dogger of Sehnde.

(*d*) The difference between the oil of the Lower and Upper Dogger.

Dr. Stutzer expresses no opinion himself, but has put this question to numerous geologists both in Germany and elsewhere, and has drawn on opinions expressed on this question at the World Petroleum Congress in London in 1933. In all 23 opinions are published : of these 13 are in favour of primary Mesozoic oil, 8 favour the migration of oil from pre-salt formations, and 2 are non-committal. In view of this it is little wonder that Dr. Stutzer comments : " The replies show how very little we know."

In conclusion, the volume is strongly recommended to anyone interested in German oil.

JAMES ROMANES.

TERTIARY FAUNAS. By A. Morley Davies, A.R.C.S., D.Sc., F.G.S. Vol. II.: The Sequence of Tertiary Faunas. London : Thomas Murby & Co., 1934. Pp. x.+252, with folding plate and 28 Figs. 15s. net.

To those who have had the good fortune to study under Dr. Davies, and to the larger circle who know him as guide and author in palæontology and field geology, this book will need no further commendation. As would be anticipated, it is thorough in treatment, candid in statement and cautious in deduction.

The work is described as " a text-book for oilfield palæontologists and students of geology," but it has a wider appeal than that indicated. Geologists may be divided into three genera (this is the reviewer's and not the

author's classification) : (1) Those who ignore palæontological data ; (2) those who co-ordinate palæontological and other field data ; and (3) those who separate their formations on purely palæontological ground. Fortunately, genera (1) and (3) are almost extinct, and their scanty remnants will draw little encouragement from this volume. To genera (2), however, its study should give many hours of pleasure and enduring profit. Modification in detail—as the author points out in his preface—is inevitable, as new facts are brought to light, but the book itself is likely to survive many editions and revisions.

Chapter I. deals with the geographical distribution of animal life, and the aids and barriers to the dispersal of the various types on sea and land. It gives, also, a detailed summary of the characteristics of the various Regions and Provinces into which these types are segregated. With reference to the differing interpretations of the facts of geographical distribution, the author maintains a strictly impartial attitude of which the closing paragraphs of the chapter are characteristic :—

"A third school has arisen more recently, founded essentially by Wegener, which agrees with the first in its belief in isostatic balance and the consequent permanence of the continents as elevated masses, but believes them capable of horizontal drift. Thus it rejects the permanence of oceans, and for the land bridges of the second school may in certain cases substitute the conception of former juxtaposition of continents now far apart.

"At the present time the three schools are engaged in a triangular duel of a highly intricate kind."

Chapter II. treats of the geological interpretation of fossils, and indicates the many and varied pitfalls which lie in the path of a too dogmatic extrapolation of data from known to new areas. Extremist views are not excluded from the catholic bibliography which terminates the chapter, but the author's moderately expressed criticisms can leave no doubt as to the caution with which such views should be treated.

Chapters III. and IV. contain a detailed account of the Tertiary faunas, their changes, successions and world-wide interrelation. A quotation will typify Dr. Davies' circumspect treatment of his accumulated data :—

". . . Genera or families equally common in Mesozoic and Cainozoic. Of these the most interesting are some which in Mesozoic times seem to have been widely distributed without climatic restriction, but are now restricted to warm seas (*Nautilus*, *Cucullæa*, *Perna*, *Spondylus*) or to cold seas (*Astartidæ*, *Cyprinidæ*, *Aporrhaidæ*). These raise the question, how far back in geological history they can safely be taken as climatic indices."

An appendix contains four tables giving approximate correlations of Tertiary marine formations and mammalian faunas. The index is adequate.

In his preface, the author states that "partly because of repeated interruptions by other duties, the writings has already been spread over more than a decade," but it is obvious that the collection of the material has occupied a much longer period.

It is to be regretted that some important oil-bearing regions have had to be treated rather summarily, but this is entirely due to the fact that the data obtained have not been made available. It is to be hoped that this book will cause the release, to the advantage of all concerned, of the results now privately held, for analysis and synthesis in future editions.

Vol. I., which will contain systematic descriptions of all important Tertiary genera of Foraminifera, Echinoidea, and Mollusca, with more general accounts of Tertiary Vertebrata and some other Invertebrate groups, is delayed during the preparation of illustrations, but its publication is promised about the end of the year. Its appearance will be awaited eagerly.

LAUNCELOT OWEN.

TREATISE ON SEDIMENTATION. W. H. Twenhofel and Collaborators. Pp. xxix.+926. Second Edition. London: Ballière, Tindall and Cox. £2 6s.

The second edition of this volume will be greatly welcomed by geologists, for there can be little doubt that it has filled a very definite want in geological literature and many workers have found it a most useful book of reference.

A treatise produced by the collaboration of a group of authors is bound to have a certain unevenness in the value of its contents, but the main criticism which could be levelled at the first edition lay rather in the lack of appreciation which it displayed of the immense wealth of European literature bearing on the subject. The references were heavily weighted in favour of American literature, and although this was somewhat natural in the case of a volume produced in the United States, yet in view of its appeal to an international public it was felt by many that this scanty recognition of European literature was somewhat unfortunate.

The newer volume is considerably enlarged. The text has been increased from 641 pages to 890 pages, and the references have been increased by nearly 800. An attempt has been made to meet the criticism referred to above, but one must still confess to the feeling, after a perusal of the volume, that although there is more reference to British work, Continental literature still has an inadequate share of attention.

It would be ungrateful not to admit that the amount of data collected is both generous in its volume and pertinent in its application. Some of the chapters are remarkably good, and oil technologists will be particularly grateful that Dr. David White, in spite of severe illness, was able to add to his original contribution on the carbonaceous sediments. Whatever varying views geologists may have on the origin of petroleum, it must be admitted that Dr. White's statement of the case of the relationship and differences between the coals and petroleum in Nature is a masterly one. After reviewing the evidence he concludes that petroleum is probably produced by the progressive devolatilisation of the carbonaceous sediments by incipient regional metamorphism in the course of geological time.

With this conclusion many of us will disagree, but we cannot help acknowledging that he has put forward a good case for the other point of view.

V. C. Illing.

The Story of Petrol. By C. Webber. London: T. Nelson and Sons, 1934. Pp. 217. 3s. 6d. net.

Although this book is primarily intended for the younger generation, it is one which can be read with absorbing interest and advantage by all. The author has treated his subject in a fascinating manner, and by dealing with it in the form of a dialogue has added considerably to the ease of reading. Geology, production, chemistry, refining, transport and utilisation are all included within the scope of the book, the opening chapter of which contains a vivid account of controlling a gusher. The book is well illustrated and can be recommended particularly to those engaged on the non-technical side of the industry, and to all who wish to obtain some knowledge of how petroleum products are obtained without necessarily studying the highly technical aspects.

George Sell.

Le Régime du Pétrole en France. L'Office National des Combustibles Liquides. By H. Gregory Thomas. Paris, Librairie du Recueil Sirey, 1934. Pp. 224. Fr. 25

The author of this work gives a particularly brilliant account of the development of the French Petroleum policy, dealing particularly with the recent legislation and discussion on the question of monopoly.

After having studied the general problem of the offices in its general aspects, he shows that it is wrong to systematically oppose all such organisations, and quite fairly in the Office National des Combustibles Liquides he sees an exception to the rule.

He gives proof of this in describing, in a quite clear and concise way, the aims, the organisation and the activities of the Office, as well as the results of its control of the Petroleum policy of France.

He concludes by a thorough study of the present system of imports, system of controlled liberty, which he considers incontestably superior to any system of monopoly.